Dual Energy X-ray Absorptiometry (DXA) in the Management of Osteoporosis

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Osteoporosis is a progressive skeletal disease characterised by a reduction in bone mass, architecture, decline in bone tissue, and increased fragility with higher risk of fracture.[1] Being one of the foremost age related health-risks, it has a reported prevalence of 30% in females and 15% in males of age above above 50 years.[2] It is characterised by a decrease in bone mineral content (BMC) and bone matrix but the composition of bone remains normal.[3] Fragility fractures associated with osteoporosis (primarily hip and spine) have a significant global financial impact. By 2025, more than three million osteoporosis-related fractures will occur annually in the United States, with an estimated impact of 25.3 billion US dollars on the national budget.[4] Therefore, it is important to adopt a pragmatic approach for an early diagnosis, assessment of fracture risk, and take preventive measures to minimise risk of fall. The dual energy x-ray absorptiometry (DXA) was introduced in 1987 and believed as a gold standard for early diagnosis of osteoporosis.[5]

DXA uses two x-ray beams of different energies (constant and pulsed) selected according to different attenuation coefficients of the bone (higher energy) and soft tissue (lower energy) of the site being acquired and analysed.[6] World Health Organisation (WHO) criteria recommend imaging non-dominant hip (or dual hip in case of fracture, arthritis, or post-arthroplasty) and antero-posterior (AP) L1-4 for estimation of bone mineral density (BMD).[6] It is advised to exclude a lumbar vertebra having morphological abnormality or bearing T-score >1SD from adjacent vertebra (at least 2 vertebrae should be used for reporting). In some cases, such as hyperparathyroidism or obese patients or when hip or spine site is not measurable, acquisition of the non-dominant distal forearm is also recommended. It is imperative for technologists to use position devices provided by manufacturers and follow the vendor's manual as well. The BMD estimated by DXA is an areal density (gm/cm^2) and is not volumetric (gm/cm^3) as DXA is a two-dimensional (2D) imaging modality.

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Received: April 23, 2024; Revised: May 27, 2024; Accepted: May 29, 2024
DOI: https://doi.org/10.29271/jcpsp.2024.06.633

The measured BMD of a patient is compared with a young normal reference standard (20 - 29 years) and the difference (in standard deviation) is expressed as T-score. Similarly, when patient's BMD is compared with normal age and gender-match reference standard, the difference (in standard deviation) is expressed as Z-score. According to WHO and the International Society for Clinical Densitometry (ISCD), manufacturers of DXA scanners should use National Health and Nutrition Examination Survey-III (NHANES-III) data for estimation of T-score for hip, while for spine and distal forearm they may use their own databases and reference standard for T-scores.[7] ISCD also recommends using country-specific reference data (if available) to calculate the Z-score, not T-score. The objective of this recommendation was to mitigate variability in DXA interpretation on different scanners due to the use of different standard databases. WHO and ISCD recommend using the lowest T-score for diagnosis in post-menopausal women and men aged ≥50 years. A T-score ≥-1.0 is considered normal, between -1 to -2.5 as osteopenia or low bone mass, ≤-2.5 as osteoporosis, and –1.0 with fragility fracture as severe osteoporosis. ISCD also recommends using the lowest Z-score for diagnosis in premenopausal, paediatric, and men <50 yr. A Z-score >-2.0 is reported as "within the expected range for his/her age" and ≤-2.0 as "below the expected range for his/her age".[7]

DXA is considered a sensitive and reliable tool for monitoring the response to anti-osteoporotic therapy. Due to the differences in various scanners' design, technique, and analysis software, it is of paramount importance to have a follow-up study on the same scanner or a cross-calibrated scanner, which is difficult if two are installed in different healthcare facilities. A change in BMD greater than the least significant change (LSC) is considered a meaningful change (+ve = improvement; -ve: deterioration), while smaller LSC means stable BMD values. It is important that every imaging facility must measure its LSC as a larger LSC denotes less precision and if it is very high then technologist(s) should be retrained. This is very crucial as the decision to continue or change the management depends upon a meaningful change in BMD on serial studies. A follow-up DXA study is usually performed after one year.

It is important to identify patients with low bone strength which reflects integration of bone quality and BMD. Major risk factors for osteoporosis and related fragility fractures include history of fracture in an adult, history of fragility fracture in first degree relative, low body mass index (BMI), current smoking, steroid

(≥5 mg/day for ≥3 months), current alcohol (≥3 units/day), and rheumatoid arthritis.[8] A low BMD is considered as a strong (not sole) predictor of future fracture risk as for every decrease in T-score increases the fracture risk by two-fold.[9] According to a landmark study by Leslie *et al*., most fragility fractures were observed in patients with BMD consistent with osteopenia or low bone mass (>-2.5).[10] Therefore, it is recommended that fracture risk assessment should employ specific risk factors in addition to BMD.[11] In 2008, Professor J Kanis of the University of Sheffield launched a Fracture Risk Assessment tool (FRAX®) which gives the 10-year probability of the fracture.[12] In recent years, country specific FRAX tool has also been introduced. The output is a 10-year probability of hip fracture and the 10-year probability of a major osteoporotic fracture (MOF; clinical spine, forearm, hip, or shoulder fracture). In the current practice, the FRAX tool is used to identify patients with osteopenia / low bone mass who will most likely benefit from anti-osteoporotic treatment. However, it is not used for patients who have already been treated for osteoporosis. Various professional societies have recommended FRAX calculation in post-menopausal women and men aged >50 years with T-scores between -1.0 and -2.5 at spine or femur.[13] To mitigate variability in treatment decisions, the American Association of Clinical Endocrinologists has recommended anti-osteoporotic treatment in patients without fracture having ≥20% MOF or ≥3% hip fracture risk.[14]

It is important to be cognizant of the fact that modifiable risk factors of subsequent fractures are osteoporosis and falls, and 10-15% of falls result in fracture.[15] So, in addition to anti-osteoporotic treatment, measures to minimise the risk of falls is of paramount importance. Falls in older people are a major health concern as they head to severe morbidity and mortality. Fall affects 28-30% of community-dwelling older persons and 40-50% of those in long-term institutions.[15] Measures to reduce the risk of falls are of major importance as 40% of older persons who have fallen once are likely to experience a fall again within a year.[16]

Therefore, osteoporosis being one of the major health issues in the older population has significant morbidity, mortality, and a huge financial impact. DXA is a gold standard modality for the early diagnosis and treatment response assessment. FRAX tool has significantly minimised the variability in the selection of patients for anti-osteoporotic therapy. The early diagnosis of osteoporosis and steps to minimise the risk of falls are sentinel steps to address this important health issue.

COMPETING INTEREST:

The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:

MUZ, NF: Concept, draft of the manuscript, approval and agreement to be accountable for all aspects of the work.

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