REVIEW ARTICLE

DUAL ENERGY X-RAY ABSORPTIOMETRY (DXA) IN PEDIATRIC POPULATION

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ABSTRACT

In pediatric population osteoporosis is not diagnosed solely on densitometric criteria. It is needs presence of one or more vertebral compression fracture to diagnose a child osteoporotic. In the absence of vertebral compression fracture, it needs a clinically significant history of two or more fractures of long bone with a Z-score ≤ -2.0 estimated by DXA imaging. Aerial BMD may significantly be affected by child s height and weight and adjustment in this regard is recommended. According to ISCD, a Z-score >-2.0 is interpreted as within expected range and Z-score ≤ -2.0 as below the expected range rather than using diagnostic terms like osteopenia or osteoporosis. Serial DXA imaging play an important role in modulation in therapeutic strategies. But to ensure precision of DXA, follow-up imaging is recommended to be acquired using same scanner and a change in BMD must be ≥ LSC to be considered as a meaningful change.

Keywords: Pediatric; DXA; Bone densitometry; Bone mineral density; interpretation; Z-score

Introduction

Osteoporosis (OP) is a metabolic disorder which causes bones to become brittle and porous and vulnerable to be fractured due to fall or subtle trauma. It affects men and women of all ages, but post-menopausal women are at higher risk and related fractures of hip, spine and distal forearm. According to the International Osteoporosis Foundation (IOF) about 44 million people in United States are osteoporotic.[1] It is projected that by 2025, annual incidence of osteoporotic fractures will be more than 03 million with an estimated cost of 25.3 billion dollar economic burden on the health system.[2] Early diagnosis of osteoporosis and treatment according to 10-year fracture risk estimates is the key to success. Assessment of bone mineral densitometry (BMD) using dual energy X-ray absorptiometry (DXA) is considered as the gold standard modality for diagnosis of osteoporosis, fracture risk calculation and assessment of response to treatment.[3]

In adults, DXA has been a pivotal tool for diagnosis of OP, fracture and treatment response assessment for last 30 years. For pediatric population, DXA utility has increased substantially over the last 10-15 years due to availability of age appropriate reference data from healthy children.[4] In adults, osteoporosis is diagnosed on densitometry criteria (T-score ≤ -2.5)

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as recommended by World health Organization (WHO).[5] But in children and adolescent , diagnosis of OP is not made on basis of densitometry criteria alone. Diagnosis of OP in pediatric needs presence of one or more vertebral compression fractures in the absence of local disease or high-energy trauma. In such children and adolescents, measuring BMD using DXA adds to the overall assessment of bone health. In the absence of vertebral compression fractures, the diagnosis of OP is indicated by the presence of both a clinically significant fracture history (≥ 2 long bone fractures by age 10 years or ≥ 3 fracture up to age 19 years) and densitometry criteria (BMD Z-score ≤ -2.0).[6]

DXA Measures: A DXA study results provide various numerical parameters. It estimates bone mineral content in grams (BMC, gm), area of bone in centimeter square (a; cm^2), areal bone mineral density (aBMD; gm/cm^2) and 10-year probability of fracture risk in percentage (%). T-score denotes the comparison of person s BMD with of healthy young adults (as standard deviation; SD). According to WHO criteria, T-score are used for diagnosis in post-menopausal women and men >50-year age.[5] In children, it is inappropriate to use T-scores as peak bone mass has yet to occur, even though scanners often generate them. While Z-score defines comparison of a person's BMD with an average person of the same age and gender (as SD). According to International Society for Densitometry (ISCD), Z-score is used for diagnosis in pediatric, premenopausal and male <50Year age.[6] This is important to understand that a BMD could be falsely low in short patients or falsely high in tall patients and additional adjustment for height or prepubertal status is recommended.[7]

Scan Sites: DXA measures BMD of trabecular bone at lumbar spine and cortical bones over femoral neck, whole-body and distal 1/3rd of the radius. In adults, WHO recommends DXA measurement over hip, lumbar spine (L1-4) and in some cases distal forearm. In pediatric population the recommended sites are the lumbar spine (anterior posterior; L1-4) and total body less head (TBLH; as 80% of skeleton is cortical bone).[8] But the reference data for TBLH is available only for 5 to 20 years of patients population.[9] TBLH scan can be used for measurement of body composition (like lean and fat mass) in children having chronic conditions. Skull is not a recommended site as it constitutes a larger portion of the skeleton and bone mineralization over skull is not affected by the nutritional or environmental factors as over rest of sites. Furthermore, skull fractures are not osteoporotic.[10,8] Hip is not a recommended site in pediatric population because of skeleton is growing which poses challenges in reproducibility and also proper positioning is very important too.[11] Distal one third of radius is recommended when spine (L1-4) or TBLH is not feasible but has limitations of poor precision and limited reference data.[9] Lateral distal femur (LDF) is also a recommended site for non-ambulatory children and DXA software for distal radius is used in this regard. This requires additional training of technologist to ensure reproducibility and the reference data is available only on Hologicfi scanner.[12]

Interpretation of DXA: In pediatric population, Z-scores alone cannot be used to diagnose OP, therefore this terminology should not appear in the pediatric report unless a clear evidence of skeletal fragility is present.[12] According to ISCD, in pediatric population, Z-score which compares the patient's BMD with age, sex and race matched reference should be used.[6] A Z-score > -2.0 SD is considered normal for his or her age.[6] A Z-score ≤-2.0 is considered as low bone mass or bone mineral density for age.[6] Term osteopenia is discouraged in pediatric DXA reporting by ISCD.[6] As mentioned before, BMC and aBMD are highly influenced by bone size, short children may have falsely low Z-scores if an additional adjustment for their height or pubertal status is not done.[7]

Reliability and Validity of DXA: It is important that physicians must be cognizant of precision or reproducibility of DXA results generated by a particular scanner. Precision error caused by machine itself is reported to be <1%.[13] But the major contributors are variation in patient positioning by technologists and motion artifacts during acquisition. To address this important aspect, technologists must have periodical reviews to ensure standardization of acquisition and analysis techniques. It is important that every imaging facility must have Least Significant Change (LSC) for their scanners and technologist too rather than relying on vendor s provided values.[1,14] On serial DXA imaging, a change in BMD values greater than LSC must be considered clinically significant.[6] Furthermore,

follow-up imaging must be performed on same scanner to ensure precision or use correction factor between two different scanners.[6]

Radiation Dosimetry: Radiation exposure from DXA is less than an X-ray chest (0.1-6 Sv) but in pediatric age group likely to have serial imaging, stochastic effects are not negligible.[6] It is recommended that serial DXA must be performed after 6-12 months to minimize radiation dose to growing children.[15]

Clinical Indications: DXA is the only recommended modality for BMD assessment in pediatric population. In children without any chronic disease, DXA is recommended when there is apparent osteopenia on a radiograph or there is clinically significant history of fracture (except stress fracture or fractures caused by high energy trauma).[15] Chronic diseases can affect bone mineralization through impaired osteogenesis, promoting bone resorption or both. In primary bone diseases like osteogenesis imperfect (OI), DXA scan plays an important role in assessing disease progression and response to therapy. A baseline DXA is advised (which may help in diagnosis of Type-I OI) before commencement of treatment followed by periodical studies after 6-12 month.[12] In inflammatory disease like rheumatoid arthritis, bowel disease or cystic fibrosis, inflammatory cascade activate RANK-ligand resulting in enhanced bone resorption. Children on steroid treatment (>0.5 mg/kg/day) have reported 6% prevalence of vertebral fracture and American College of Radiology (ACR) recommends DXA scan if therapy is planned for >3months.[16] Children with malignancies are prone to have reduced BMD due to treatment, malnutrition, immobility, hormone disruption or inflammatory response. A baseline DXA study is suggested 2 years after completion of treatment or at 18 years in cancer survivors.[17] Similarly insufficient intake of protein, calcium and Vitamin-D or eating disorder like anorexia nervosa are associated with reduced BMD. ACR recommends DXA in girls and adolescents with eating disorders and anorexia nervosa.[18] Weight bearing physical activity is important for bone health and children with limited or no mobility like paralysis, muscular dystrophy, cerebral palsy are prone to have reduced BMD and higher risk for fractures.[17] DXA imaging plays an important role in monitoring bone health and treatment response in these clinical scenarios.

Conclusion

In pediatric population osteoporosis is not diagnosed solely on densitometric criteria. It is needs presence of one or more vertebral compression fracture to diagnose a child osteoporotic. In the absence of vertebral compression fracture, it needs a clinically significant history of two or more fractures of long bone with a Z-score $\leq$ -2.0 estimated by DXA imaging. Aerial BMD may significantly be affected by child s height and weight and adjustment in this regard is recommended. According to ISCD, a Z-score >-2.0 is interpreted as within expected range and Z-score $\leq$ -2.0 as below the expected range rather than using diagnostic terms like osteopenia or osteoporosis. Serial DXA imaging play an important role in modulation in therapeutic strategies. But to ensure precision of DXA, follow-up imaging is recommended to be acquired using same scanner and a change in BMD must be $\geq$ LSC to be considered as a meaningful change.

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