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Original Article

Reliability of Lateral Distal Femur Dual-Energy X-Ray Absorptiometry Measures

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Abstract

Dual-energy X-ray absorptiometry (DXA) of the lateral distal femur (LDF) has been suggested for patients with metal implants or joint contractures preventing DXA scanning at conventional anatomical sites. This study assessed variability in LDF DXA measures due to repeat scanning using data from 5 healthy young adults who had 3 unilateral scans with repositioning between scans. Variability due to image analysis was evaluated in 10 children who underwent bilateral LDF scans with each scan being analyzed 3 times by 2 raters. Regions of interest (ROIs) were defined in the anterior distal metaphysis (R1), metadiaphysis (R2), and diaphysis (R3) as described previously. An additional region (R4) was defined in the metaphysis similar to R1 but centered in the medullary canal. Variability was consistently lower for bone mineral density than for bone mineral content and bone area; R4 was more repeatable than R1; and variability because of repeat scanning was negligible. These results suggest that DXA measures of the LDF are reliable and may be useful when standard DXA measures cannot be obtained, but it is recommended that a central, rather than anterior, ROI be used in the metaphysis.

Key Words: Bone mineral density; DXA; lateral DXA; reliability.

Introduction

Low bone mass may lead to an increased risk of fractures and may be a precursor to osteopenia and osteoporosis, even in pediatric populations. Dual-energy X-ray absorptiometry (DXA) is commonly used to assess bone mass through measurements of bone mineral content (BMC) and bone mineral density (BMD). DXA has been preferred over other bone assessments, particularly in clinical settings, because of its low cost, low radiation exposure, ease of use, and demonstrated relationship to fracture risk in adults *(1,2)*.

DXA protocols typically examine the whole body, lumbar spine, and/or hip (proximal femur) because these are the most common fracture sites in the elderly. However, in some pediatric populations such as children with cerebral palsy or spina bifida, accurate data often cannot be obtained from these sites because of contractures, metal implants, and positioning problems. Furthermore, because correlations between different sites decline as density decreases, it is important to measure BMD at sites that are prone to fracture because of low bone density *(3)*. For these reasons, the lateral distal femur (LDF) scan has been suggested as an alternative technique for performing DXA measurements in pediatric patients *(4,5)*.

The LDF scan has been successfully used in healthy children *(5,6)*, children with cerebral palsy *(4,7)*, children with muscular dystrophy *(7)*, children with spina bifida *(8)*, and

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The study was conducted at Children's Hospital Los Angeles, Los Angeles, CA, USA.
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children undergoing chemotherapy (9). Although LDF reliability has been reported within individual studies (4,5), reliability of the LDF scan acquisition and analysis has yet to be systematically investigated. Obtaining accurate and reliable bone mass measurements is important for both research and clinical applications. Therefore, the purpose of this study was to examine the reliability of LDF DXA scans by assessing intrarater and interrater reliability of image analysis and variability associated with repeat scanning.

Materials and Methods

LDF scans were performed on 3 groups of participants: 5 typically developing children (TD group), 5 ambulatory children with myelomeningocele (myelo group), and 5 healthy adults (adult group). Subjects in the TD and myelo groups were randomly selected from a previous research study; subjects in the adult group were volunteers for quality assurance testing. The study was approved by the Committee on Clinical Investigations at Children's Hospital Los Angeles.

A single certified radiology technologist performed all DXA acquisitions using a standard clinical densitometer (Delphi W; Hologic, Inc., Bedford, MA). The LDF scan was performed using the forearm protocol with the subject lying on the side being measured. Regions of interest (ROIs) were defined in the anterior distal metaphysis (R1), metadiaphysis (R2), and diaphysis (R3) as described by Henderson et al (5). To better represent cancellous bone, an additional region (R4) was defined in the metaphysis similar to R1 but centered in the medullary canal (Fig. 1). To define the height of the ROIs, the width of the femur was measured in the diaphysis where the width was fairly consistent. All ROIs had a height of 2 times the width of the femoral shaft. The ROIs were placed end to end starting with R1 and R4, which originated just proximal to the distal growth plate. The width of R2 and R3 encompassed the entire width of the diaphysis. R1 had a width equal to half the width of the growth plate and was positioned extending posteriorly from the anteriosuperior edge of the distal growth plate. R4 had a width equal to half the width of the femoral shaft and was positioned in the center of the medullary canal. If the femur was angled, R1 and R4 were angled to encompass the appropriate region. This was done first by angling R4 to form a parallelogram that followed the angle of the cortical bone at the distal end of the femur where R1 and R4 are placed; to ensure that the area remained the same, the left and right corners were moved the same distance. R1 was adjusted to the same angle as R4. BMC, projected bone area (area), and areal BMD were measured for each ROI.

Two main sources of variability were investigated: (1) variability due to image acquisition and (2) variability due to image analysis.

Variability due to image acquisition was examined using data from the adult subjects. These subjects underwent unilateral DXA scanning 3 times with repositioning between scans; each scan was analyzed once by a single rater. Coefficients of variation (CVs) were derived for each measure for each subject. Differences between each pair of measurements were tested for significance from 0 using the Student's paired *t*-test.

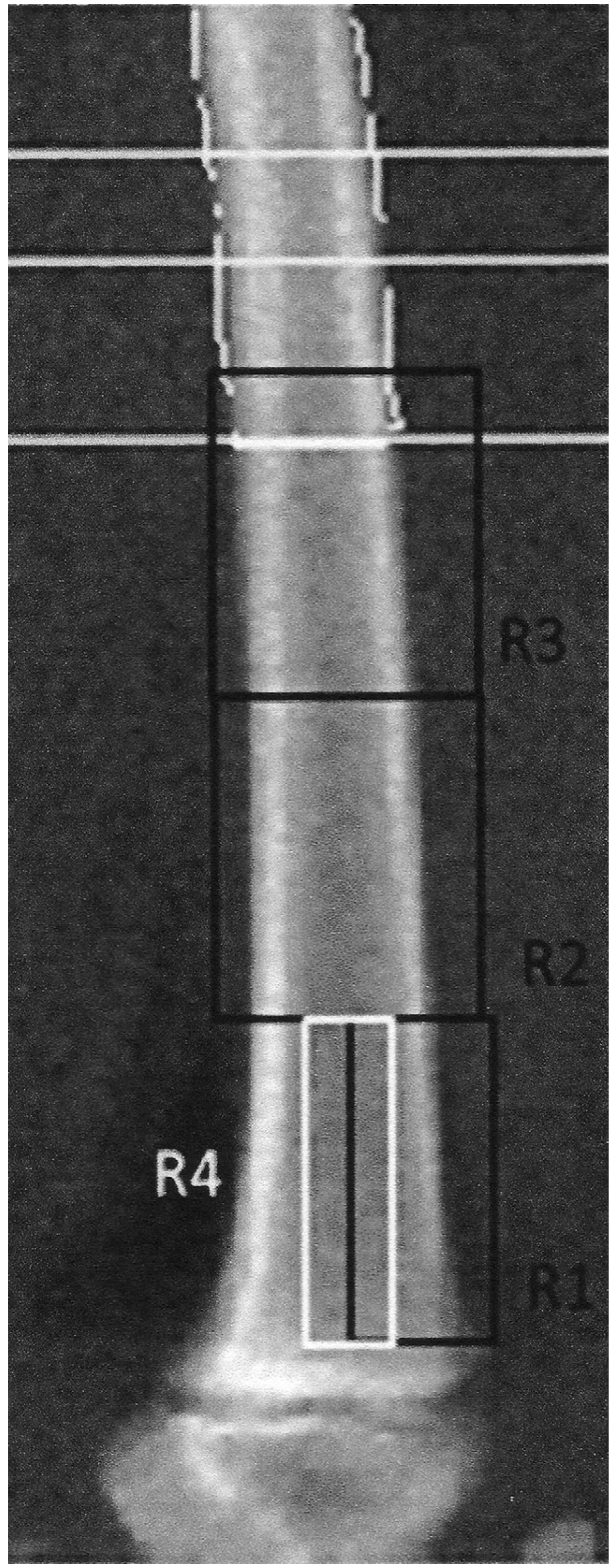

Fig. 1. Regions of interest for the lateral distal femur scan. R1, R2, and R3 are defined as described by Henderson et al (5). R4 is similar to R1 but is centered in the medullary canal instead of encompassing the anterior cortex.