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Original Article

Adaptation of the Lateral Distal Femur DXA Scan Technique to Adults With Disabilities

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Abstract

The technique that best addresses the challenges of assessing bone mineral density in children with neuromuscular impairments is a dual-energy X-ray absorptiometry (DXA) scan of the lateral distal femur. The purpose of this study was to adapt this technique to adults with neuromuscular impairments and to assess the reproducibility of these measurements. Thirty-one adults with cerebral palsy had both distal femurs scanned twice, with the subject removed and then repositioned between each scan (62 distal femurs, 124 scans). Each scan was independently analyzed twice by 3 different technologists of varying experience with DXA (744 analyses). Precision of duplicate analyses of the same scan was good (range: 0.4%–2.3%) and depended on both the specific region of interest and the experience of the technologist. Precision was reduced when comparing duplicate scans, ranging from 7% in the metaphyseal (cancellous) region to 2.5% in the diaphyseal (cortical) region. The least significant change was determined as recommended by the International Society for Clinical Densitometry for each technologist and each region of interest. Obtaining reliable, reproducible, and clinically relevant assessments of bone mineral density in adults with neuromuscular impairments can be challenging. The technique of obtaining DXA scans of the lateral distal femur can be successfully applied to this population but requires a commitment to developing the necessary expertise.

Key Words: Adults; cerebral palsy; distal femur; DXA scan; skeletal fragility.

Introduction

It has been well established that children and adolescents with neuromuscular impairments that limit or preclude ambulation have low bone mineral density (BMD), and many will sustain fractures with minimal trauma. Although multiple aspects of bone health have been examined in reasonably large series of children with conditions such as cerebral palsy (CP) *(1)*, very little has been published looking at these same issues in even smaller groups of adults with CP *(2,3)*.

One obstacle to assessing bone health in persons with CP has been the difficulty in obtaining dual-energy X-ray absorptiometry (DXA) scans that are both technically feasible and clinically relevant. Joint contractures, scoliosis, hip dysplasia, and metallic implants frequently prevent reliable measures of BMD by DXA in the whole body, proximal femur, and

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lumbar spine where BMD is commonly measured. However, a more subtle issue often overlooked is whether the particular BMD assessment is at all relevant to the clinical problem of fractures in that specific population.

In children with disabilities, it is not clear whether there is in fact a relationship between DXA measures of lumbar spine BMD and fracture risk *(4,5)*. Furthermore, it has been found that quantitative computed tomography measures of volumetric bone density in the lumbar spine of children with CP do not correlate with the degree of motor impairment and thus clearly do not reflect skeletal fragility *(6)*.

To address these difficulties in obtaining clinically meaningful assessments of bone density, a new technique was developed using DXA measurements of the distal femur projected in the lateral plane *(7,8)*. The distal femur is the most common site of fracture in persons with severely limited mobility, and metallic fixation is uncommon in this region. Although the lateral distal femur (LDF) DXA scan is obtainable in persons without neurological disability, even those with contractures can usually be appropriately and comfortably positioned. The proven relationship between distal femur BMD and fracture risk *(5)*, the technical feasibility of obtaining a reliable assessment of BMD in the distal femur, and the publication of more robust normal pediatric reference data *(9)* establish the LDF DXA as the clear technique of choice for assessment of BMD in children and adolescents with neuromuscular disabilities or significantly impaired mobility.

However, it is critical to note that the LDF DXA protocol and regions of interest (ROIs) were developed for the pediatric age group, and the published analysis technique relies on the growth plate as a reference point *(8)*. The purpose of this present study is to describe the adaptation and application of the LDF DXA scan technique to adults with CP and to assess reproducibility and precision of these measures in this population.

Materials and Methods

As part of ongoing studies looking at health and fitness in adults with CP, there were 100 adult subjects with CP who had distal femur DXA scans obtained as part of their evaluation; a subset of 31 subjects were selected for this study. This subset of subjects had the scans obtained by 1 of 2 technologists, had no metallic implants in the scanned regions, and were willing to undergo duplicate scans of both the right and left distal femurs. Duplicate scans of each distal femur were obtained with repositioning of the subject between every scan. Bilateral duplicate scans in 31 patients provided 124 total scans of the distal femur. DXA scans were acquired on a Hologic Discovery A scanner (Bedford, MA) using APEX software, version 3.3. The study was approved by the University of North Carolina at Chapel Hill Institutional Review Board, and informed consent was obtained from all participants.

The mean age of the 31 subjects was 27.8 ± 8.5 yr (±standard deviation), ranging from 21.4 to 58.8 yr. Seven subjects were female (23%), 25 were Caucasian (81%), 4 were African American (13%), and 1 each were Hispanic and Asian. Severity of CP is commonly graded level I through V based on the Gross Motor Functional Classification System (GMFCS) *(10)*. Eleven subjects (35%) were GMFCS level I at the time of the evaluation, meaning they were fully ambulatory with no significant limitations. Thirteen subjects (42%) were GMFCS level II with some impairment in ambulation; these subjects generally ambulate with external supports or braces and may use a wheelchair for long distances out in the community. Five subjects (16%) were GMFCS level III, meaning that external supports were needed for ambulation and a wheelchair was consistently used out of doors and for long distances. Two subjects (6%) were GMFCS level IV; these persons are wheelchair dependent and require significant external support to be in a standing position and usually some support even to sit. No subjects were at the most severely involved end of the spectrum (GMFCS level V).

Technique for Scan Acquisition

The LDF scan is acquired using the forearm mode on the DXA scanner. The subject is placed on the table in a side-lying position on the side being measured. The femoral shaft follows the center longitudinal axis of the scanner table. The limb on top, which is not being scanned, is flexed forward and supported on foam blocks so it will not directly overlay the lower scanned limb. Sandbags and additional foam blocks are used as needed to help comfortably stabilize the patient. The technologist assures that the knee is in a true lateral position to avoid technical issues encountered with femoral rotation. Figure 1A shows a well-positioned distal femur scan and contrasts with Fig. 1B showing a rotated and poorly aligned scan.

Technique for Scan Analysis

The principles of analysis for the LDF remain the same for scans acquired on adults; during scan analysis, the technologist creates 3 ROIs by using subregion analysis software, starting distally and moving up the shaft proximally. The ROIs are proportionate to the width of the femoral shaft; femur shaft width is used to determine the height of the ROIs. The 3 ROIs contain significantly different proportions of cortical and cancellous bone and, therefore, results from each ROI are treated independently.

In a child, the base of region 1 is defined by the growth plate *(8,9)*. In adults, however, that landmark is not available, so the base of region 1 is defined by the point where the condyles join the femoral shaft posteriorly. Figure 2 shows the landmark used in the adult LDF analysis. Further details and instructions for scan acquisition and analysis can be found at www.lateraldistalfemur.org.

Scan Analyses

Three clinical centers that use DXA scanning in adults with neuromuscular impairments participated in this project. The experience of the technologist at each center involved in this work ranged widely. The lead technologist (HHK) has been extensively involved in the development of the