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Original Article

Errors in Patient Positioning for Bone Mineral Density Assessment by Dual X-Ray Absorptiometry: Effect of Technologist Retraining

Sasivimol Promma,[1] Chanika Sritara,[,1] Saowanee Wipuchwongsakorn,[1] Krisanat Chuamsaamarkkee,[1] Chirawat Utamakul,[1] Wichana Chamroonrat,[1] Arpakorn Kositwattanarerk,[1] Yoch Anongpornjossakul,[1] Kanungnij Thamnirat,[1] and Boonsong Ongphiphadhanakul[2]*

[1]*Department of Diagnostic and Therapeutic Radiology, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand; and* [2]*Department of Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand*

Abstract

Improper positioning is one of the factors that can lead to incorrect bone mineral density (BMD) results. This study aimed to assess the frequencies of erroneous positioning during three periods: before retraining of the technologists (BR), after retraining (AR), and at the current timepoint 8 years after retraining (C). The BMD images of the first 150 consecutive patients who underwent DXA of the lumbar spine and hip during each of the three periods were retrospectively reviewed. Patients were excluded if they had severe scoliosis, rendering proper positioning impossible. Each BMD image was assessed by an International Society of Clinical Densitometry certified clinical densitometrist who was blinded to the date of the initial examination. For the lumbar spine in the BR group, the criteria frequently not met were inclusion of both iliac crests (33.8%), straightness (30.3%), and midline positioning (20.4%); the respective frequencies were significantly reduced to 0.8%–5.6%, 2.1%–3.0%, and 0%–2.8% in the AR and C groups ($p < 0.05$). For the hip in the BR group, the criteria frequently not met were straightness (52.8%) and internal rotation (21.8%); the respective frequencies were significantly reduced to 0%–4.2% and 8.3%–8.4% in the AR and C groups ($p < 0.05$). Overall improper positioning in the BR group was 49.3% and 57.3% at the lumbar spine and the hip, respectively; the respective frequencies were reduced to 9.3% and 12.7% in the AR group, and to 2.7% and 7.3% in the C group. The least significant change values for the lumbar spine, femoral neck, and total hip also became smaller after retraining. Retraining the technologists improved patient positioning, as evidenced by the decreased frequencies of erroneous positioning and the improved least significant change values after the retraining.

Key Words: Bone mineral density; dual-energy X-ray absorptiometry; least significant change; patient positioning; precision error.

Introduction

Osteoporosis is a major health threat to our aging society; the condition is defined as a skeletal disorder characterized by compromised bone strength predisposing to increased risk of fracture *(1)*. Osteoporosis diagnosis and management requires bone mineral density (BMD) measurement using dual-energy X-ray absorptiometry (DXA).

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*Address correspondence to: Chanika Sritara, MD, CCD, Department of Diagnostic and Therapeutic Radiology, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok 10400, Thailand. E-mail: chanika.sri@mahidol.edu

Serial monitoring of BMD is used to assess the response to therapy and facilitates the decision to initiate or change medication. However, BMD assessments are reliable only when the measurement technique is appropriate and precise. Incorrect BMD assessments can result from improper positioning of the patient during the procedure, which can result in inappropriate diagnoses *(2)* and can lead to either unnecessary medication or loss of treatment opportunity.

Most technologists are initially trained by DXA manufacturers when a DXA scanner is purchased; this training involves learning how to position the patients, how to operate the DXA scanner, and how to analyze the results. According to the International Society of Clinical Densitometry (ISCD) position statements *(3)*, each DXA facility should determine its precision error and calculate the least significant change (LSC). The ISCD position statement also suggests minimum acceptable LSC values for the lumbar spine, the femoral neck, and the total hip, and recommends technologist retraining if any of these values are exceeded *(4)*. One of our 2 technologists who undertook precision assessment earlier in 2008 had a total hip LSC that exceeded the acceptable value. To maintain professional standards, our supervising technologists, with at least 5 yr' experience with DXA, and a nuclear medicine physician (who had 16 yr of experience in DXA) underwent retraining organized by the ISCD in October 2008. Those who underwent the retraining then transferred their knowledge to the rest of our technologists and organized training courses for technologists from other facilities.

We hypothesized that retraining the technologists improved patient positioning and LSC. The present study aimed to assess the frequencies of erroneous positioning during 3 periods: before the retraining (BR), soon after the retraining (AR), and at the current timepoint (C, nearly 8 yr after the retraining).

Patients and Methods

The study protocol was approved by the Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand. Retrospective reviews of patient positioning in BMD images of the lumbar spine and the hip were performed using the Discovery A DXA system (Hologic, Bedford, MA) in fast array mode, during each of the 3 periods. The BR period was set to represent the performance of the technologists at baseline (December 2007), the AR period was soon after retraining (May 2009), and the C period represented the current time (March 2016). The BMD images of the first 150 consecutive patients who underwent DXA of the lumbar spine and hip during each of the 3 periods were retrieved from the picture archiving and communication system. The exclusion criterion was severe scoliosis that rendered proper positioning impossible. As the DXA image portrays only T12–L5 vertebrae, not the entire thoracolumbar column, the Cobb angle could not be properly measured; therefore, severe scoliosis in the present study was defined as a vertebral rotation with a grade of ≥2 (measured with the Nash-Moe method *(5)*), or the inability to draw a straight line passing through the L1–L4 spinous processes (Fig. 1); this line will be subsequently referred to in this article as the lumbar vertebral axis line. To avoid bias, each BMD image was prepared for blind assessment on a PowerPoint (Microsoft Corporation, Redmond, WA) slide without any patient information or date of examination. Each image size was adjusted to maximize visualization without distorting the vertical and horizontal ratios. In addition, we calculated the LSC of the BMD at the lumbar spine, the femoral neck, and the total hip, performed by 7 technologists after retraining during 2009–2016 in 30 patients according to the ISCD official positions *(4)*. The coefficient of variation obtained from a daily quality control procedure using a spine phantom was <1.5% *(6)*.

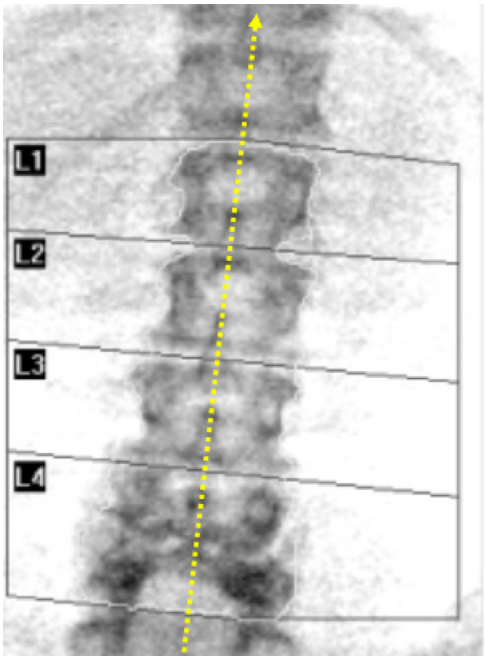

Fig. 1. Example of an eligible bone mineral density image. Eligible images had a lumbar vertebral rotation with a grade of ≤1, and the spinous processes of L1–L4 vertebrae could be joined by a straight (yellow dotted) line, subsequently referred to as the lumbar vertebral axis. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Assessment of Patient Positioning

Each BMD report was assessed by an ISCD-certified clinical densitometrist who was blinded to the date of the examination. For the lumbar spine positioning to be considered proper, the spine must be straight and placed in the midline of the image, with T12 and L5 vertebrae as well as both iliac crests included. For the hip positioning, the femoral shaft must be straight, such that its axis is paral-