

Original Article

The Effect of the Lumbar Vertebral Malpositioning on Bone Mineral Density Measurements of the Lumbar Spine by Dual-Energy X-Ray Absorptiometry

Sina Izadyar,*¹ Shima Golbarg,² Abbas Takavar,² and Seyed Salman Zakariaee²

¹Department of Nuclear Medicine, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran; and ²Department of Medical Physics and Biomedical Engineering, Faculty of Medicine, Tehran University of Medical Sciences, Tehran, Iran

Abstract

A significant discrepancy between the results of previous human and phantoms studies is identified regarding the effects of vertebral positioning on bone mineral density (BMD) measurements. We aimed to evaluate the effects of lumbar vertebral positioning on BMD measurements by dual-energy X-ray absorptiometry in a human cadaveric spine phantom. A spine phantom was designed using L1–L4 vertebrae harvested from a 48-year-old male cadaver without coronal or sagittal deformity. The spine phantom was scanned by DEXXUM T bone densitometer in a constant scanning speed of 30 mm/s and resolution of 1.0×1.0 mm. BMD values were measured in a positive and negative lumbar lordosis and kyphosis tilt angles in the sagittal plane, from 0° to 35° , with 7° increments. Also BMD values were measured in axial and lateral rotations with 5° increments. Projectional dual-energy X-ray absorptiometry measurements are significantly affected by positioning of the lumbar spine, more severely affected by kyphotic curvature, but also by axial and lateral rotational scoliosis as well as lordotic curvature. Increasing the severity of lordosis and kyphosis curvatures leads to false reduction of BMD value up to 17.5% and 11.5%, respectively. Increasing the degree of lateral and axial rotational scolioses results in a false decrease in BMD measurements by up to 10.8% and 9.6%, respectively. To achieve the most accurate scanning results, error sources and abnormal positioning should be identified and minimized as much as possible. If not correctable, they should be taken into consideration while interpreting the results.

Key Words: Absorptiometry; bone malposition; densitometry; DXA scan; scoliosis

Introduction

Osteoporosis is by far the most common metabolic bone disease, mainly involving the older population. As osteoporosis is generally an asymptomatic disease, bone mineral density (BMD) measurements have been widely employed as the main screening and diagnostic tool. Previous

studies have shown that BMD values are inversely associated with the risk of pathological fractures (1–3). Accordingly, BMD values have been directly translated and incorporated to the management algorithms and guidelines of osteoporosis, which emphasizes on the importance of accurate measurement of BMD for appropriate management of these patients.

Dual-energy X-ray absorptiometry (DXA) is the most commonly employed imaging technique to evaluate for osteoporosis and has been considered as the most cost-effective method for BMD measurements. However, this method is known to have some limitations and its BMD values are affected by several confounding factors (1,4).

Received 10/26/15; Revised 11/24/15; Accepted 12/1/15.

*Address correspondence to: S. Izadyar, MD, Department of Nuclear Medicine, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran. E-mail: sizadyar@yahoo.com

Most importantly, DXA is a projectional technique that lacks the potential for bone volumetric demonstration. It is mainly dependent on 2-dimensional coronal surface area measurements on coronal planes and bone mineral content (BMC) evaluation by differential absorption of 2 different photon energies. Therefore, any osseous deformity and abnormality that affect projectional presentation of the osseous structures on the coronal plane can potentially affect the output of BMD measurements (3). For example, this is true for scoliosis or any type of axial/lateral rotation or lordosis/kyphosis curvature of the lumbar spine in case of lumbar spine BMD measurements. Also, in BMD measurements by DXA, the most important source of error has been reported to be improper positioning of the patient (5–9).

A significant discrepancy between the results of human studies and phantom models is identified, with phantom studies suggesting decreased BMD measurements as the rotation angle increases (3,5) and human studies reporting increased BMD with scoliosis (6,7). Therefore, development of a phantom that audits the accuracy of simulation is becoming increasingly more important. In the present study, we aimed to evaluate the effects of lumbar vertebral positioning on BMD measurements by DXA in a human cadaveric spine phantom.

Material and Methods

In the current study, we designed a spine phantom using L1–L4 vertebrae harvested from a 48-year-old male cadaver without coronal or sagittal deformity. All soft tissues were removed and the harvested spine was embedded in a rectangular water phantom with a dimension of $50 \times 30 \times 30 \text{ cm}^3$. Each vertebral body was fixed in a plastic stand within the water phantom, which was specifically developed for positioning the specimens. The plastic stand was equipped with markings calibrated with the degree of rotation from the neutral midline position. Both posterior tips of the lumbar spine facets were placed in contact with the vertical part of the plastic stand.

The spine phantom was scanned by DEXXUM T (Osteosys Co., Ltd., Seoul, South Korea) bone densitometer in a constant scanning speed of 30 mm/s and a resolution of $1.0 \times 1.0 \text{ mm}$. The BMC and biplanar vertebral segment area of each lumbar vertebral body as well as L1–L4 lumbar segments were measured to calculate BMD. The BMC, area, and BMD values are measured in gram, square centimeter, and gram per square centimeter, respectively. These values were evaluated with the spine in the midline nonrotated, nonangulated neutral position, true anteroposterior projection, which was achieved by laying the L2–L4 vertebral bodies horizontally on the plastic stand. Subsequently, to evaluate variations of BMD with respect to variations in lordotic and kyphotic curvatures, the abovementioned values were measured in a wide range of positive and negative lumbar lordosis tilt angles solely in the sagittal plane, from 0° to 35° , with 7° increments

compared to the ex-position using Cobb's method (8). For axial rotation, each vertebra was glued on a prepared plastic stand (with the same height) fixed on a plastic plate in the water phantom. Axial rotation angles were created from 0° to 30° with 5° increments. Finally, to evaluate variations of BMD with respect to variations in lateral scoliotic curvatures, the same values were measured in a wide range of lateral tilt angles solely in the coronal plane, from 0° to 45° , with 5° increments.

To reduce the possible errors in region of interest positioning, all region of interest selections and measurements were performed by the same scientist. The quality control procedure was performed before measurements as per guidelines of the manufacturer and the precision error was set at 1%.

Statistical Analysis

All DXA readings for each neutral and tilted/rotated positions were repeated 3 times and average measurements were recorded to minimize the effect of technical or statistical errors on the results. The mean and coefficient of variation for DXA measurements of each neutral and tilted/rotated position were calculated. Considering the neutral position as the baseline value, the percentage of deviation from the baseline value was calculated for each tilted/rotated position. Linear regression analysis was used to evaluate the relationship between the degree of tilted/rotated angles of the vertebrae and BMD values. For all tests, differences with p values less than 0.05 were considered significant.

Results

BMD values with respect to different degrees of lordotic and kyphotic curvatures, as well as lateral and axial rotations for the L1–L4 segments are shown in Figs. 1–4, respectively.

Discussion

Previous studies have tried to investigate the effects of projectional presentation of the spine on BMD measurements mainly by examining the custom-built phantoms or patients with scoliosis. However, these studies suffered from several limitations, such as confounding factors in human studies. These include the effects of patient body habitus, age, sex, menopausal status, other underlying diseases and medical or surgical treatments, facet osteoarthritis, and endplate sclerosis, which may have a significant impact on BMD assessment with DXA scanning. Determining the actual effects of these confounding factors on the final results of DXA scanning is impractical in clinical settings. Studies on patients with scoliosis have been limited by the fact that, along with coronal deformity, many of these patients have significant vertebral body rotation as well, which could theoretically increase the apparent vertebral body

Download English Version:

<https://daneshyari.com/en/article/8723269>

Download Persian Version:

<https://daneshyari.com/article/8723269>

[Daneshyari.com](https://daneshyari.com)