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Original Article

Clinical Implications of Hip Flexion in the Measurement of Spinal Bone Mineral Density

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Abstract

The aim of this study was to investigate if differences in leg positioning affect spinal bone mineral density (BMD) measurements and the detection of low bone mass. Subjects included 1039 Japanese patients, 878 women and 161 men (mean ages: 67 and 71 years, respectively). Spinal BMD (L1–4) was measured using dual-energy X-ray absorptiometry (DXA) with patients lying in 2 different positions: (1) supine on the scanning table with hips flexed and knees flexed over a 90° support pad (the standard position) and (2) simply supine (the supine position). Predictive indices were calculated for spinal DXA acquired with patients in the supine position. A BMD *T*-score of −2.5 or lower was set as the threshold for low bone mass. For the standard and the supine positions during scanning in women, BMDs were 0.911 and 0.915 g/cm^2, respectively; in men, they were 1.117 and 1.124 g/cm^2, respectively. The estimated systematic bias in BMD between the positions was 0.42% (95% confidence interval: 0.24, 0.59; $p = 0.009$). Random errors in the densitometry measurements for the standard and supine positions were 0.66% and 0.84%, respectively. There was no significant difference between the errors ($p = 0.164$). The likelihood ratios of a positive and negative test for the detection of low bone mass following supine DXA were 121.0 and 0.066, respectively, compared with results acquired using the standard position. In conclusion, DXA measurements acquired with patients in the supine position slightly overestimated BMD vs the standard position. However, the clinical equivalency between the positioning methods for DXA is preserved to the extent that low bone mass can be reliably detected in the supine position.

Key Words: Bone mineral density; dual-energy X-ray absorptiometry; lumbar spine; osteoporosis; supine position.

Introduction

Osteoporosis is a major health concern, especially in elderly women, and it increases the incidence of bone fracture and ensuing morbidity. Thus, fracture prevention is the primary therapeutic goal when individuals have osteoporosis. Although several factors, including patient history, should be considered prognostic for osteoporosis, bone mineral density (BMD) measured by dual-energy X-ray absorptiometry (DXA) is still the primary determiner of a diagnosis of osteoporosis.

Of all the sites at which BMD is measured, femoral BMD best predicts the risk of hip fracture *(1,2)*; femoral DXA is performed worldwide for the purpose of diagnosing osteoporosis. The International Osteoporosis Foundation and the National Osteoporosis Foundation both suggest measuring bone density at the hip to diagnose osteoporosis in

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the elderly (3,4). In contrast to assessing femoral BMD, assessing spinal DXA remains popular in Japan. The prevalence of spinal compression fractures, the risk of which may be predicted by spinal BMD (1), is relatively high in Japan (5). Furthermore, spinal BMD decreases earlier than does femoral BMD, suggesting the importance of the spinal BMD measurement in the diagnosis of osteoporosis.

BMD evaluations at both the spine and hip are recommended by the International Society for Clinical Densitometry, the North American Menopause Society, and the most recent Japanese Guidelines for the Prevention and Treatment of Osteoporosis (6–8). We have previously reported that there are substantial discrepancies between the values for spinal BMD and femoral BMD in patients with osteoporosis; therefore, the measurement of both spinal BMD and femoral BMD should be recommended (9). We have also previously described how comparison of bilateral femoral BMDs may be needed to more accurately diagnose osteoporosis (10). These findings have demonstrated why measurement of BMD at the lumbar spine and bilaterally in femurs is recommended to more accurately diagnose osteoporosis.

In general, to acquire a spinal BMD measurement using DXA, a patient has to lie supine on the scanning table with hips flexed and knees flexed over a 90° support pad to reduce the lumbar lordosis (LL) and to open the intervertebral spaces. It is not rare to see hyperkyphosis due to a compression fracture in the thoracic spine or lumbar degeneration in aged patients with osteoporosis. Also, lumbar degeneration reduces lumbar mobility. Thus, it is considered that raising the legs may not always open lumbar disks and that hyperkyphosis might cause the caudal portion of the lumbar portion of the spine to rise, both of which could cause the lumbar tilt from the view of the lateral sides.

Only a few reports compare spinal BMD measurements with and without 90° hip flexion. Lekamwasam et al previously performed spinal BMD measurements using DXA with standard (with hip flexion) and nonstandard (supine position) scanning positions in 54 postmenopausal women, and reported that there was a strong correlation ($r = 0.99$) and no significant difference (median 0.48%, interquartile range: −2.3 to 0.9) between the BMD measurements obtained at each position (11). The report suggests that a more clinically convenient method can be used without forgoing precision. However, the number of cases in their report was small. The report did not describe whether or not hip flexion was required when spinal BMD was measured.

We hypothesized that the supine position was as valid as the standard position when performing spinal DXA for the diagnosis of osteoporosis. This study was performed with both a large sample size and a multifaceted approach to clarify whether differences as a result of patient positioning are significant for supine spinal DXA measurements vs standard positioning for spinal DXA measurements.

Materials and Methods

We performed spinal DXA scans of patients in the supine position vs the standard position for the purpose of diagnosing osteoporosis based on analyses to verify the precision of measurement, estimating the difference in BMD measurements between the 2 scanning positions, and to validate the detection of low bone mass resulting from a supine spinal DXA scan.

Subjects

A total of 1039 Japanese patients, none of whom had previously received any examination or medical treatment for osteoporosis, first visited our institution between 2005 and 2006 out of concern for their bone health. An interview in advance helped us confirm that these patients had no radiopaque implants in the scanning region of interest (ROI). All subjects provided informed consent for study participation and underwent a DXA scan for measurement of BMD before receiving any treatment for osteoporosis. The study protocol was approved by the Ethics Committee of Shinshu University School of Medicine, Japan.

Measurement Variables

Spinal BMD was measured using a DXA fan-beam bone densitometer (Lunar Prodigy; GE Healthcare, Waukesha, WI) at the L1–4 levels of the posteroanterior spine. Two scans were performed for each subject. The first scan was done with the subject's hips and knees flexed, using a leg-positioning cushion provided by the manufacturer for support, which was the standard position. The second scan was performed while the subject's legs were flat on the scanning table, in a supine position. All data were used for analysis, regardless of the presence of degenerative or traumatic vertebral changes.

Data Analysis

A measurement value difference between the 2 types of positions is composed of random error and systematic bias. We assessed the random error by performing the International Society for Clinical Densitometry's precision test and assessed the systematic bias with the estimation of the mean difference from the large sample.

First, to gauge operator reproducibility, measurement precision was calculated in 21 subjects, who were scanned a total of 6 times with repositioning after each scan; 3 scans were performed with the patients positioned in the standard position and 3 scans were performed while the patients were in the supine position. These measurement values were used to calculate position-specific coefficients of variation (CVs) and the least significant change. Because of such special DXA execution, these 21 subjects were not included in the data.

Next, we estimated the difference in bone mineral content (BMC), the area in the ROI, and BMD between