Bone Mineral Density of the Hip Measured with Dual-Energy X-Ray Absorptiometry in Normal Elderly Women and in Patients with Hip Fracture

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Abstract. Bone mineral density (BMD) was measured by dual-energy X-ray absorptiometry (DEXA) in 133 normal females on five regions of the femoral site: neck, trochanteric, intertrochanteric, Ward's triangle, and total area of the proximal femur. One hundred and twenty-five women (56 older than 65, range 65-97, and 69 with an age range of 21-65) were also examined for spinal bone mineral density. The mean in vivo precision (CV%) of the measurements with respositioning assessed on five young and eight elderly patients was ranged from 0.7% to 1.7% but lower for Ward's triangle (CV=2.95% and 3.87%). Between 30 and 90 years, a linear age-related bone mineral decrease was found at all sites with a similar magnitude of bone loss for the femoral neck, total or intertrochanteric regions (-33% to -39%). A greater decrease was found for the Ward's triangle region (-61%). In the subgroup of elderly women (65-97 years old), the lumbar BMD measured with an anteroposterior incidence did not decrease significantly with age, contrasting with an average 27% decrease of the BMD of the hip between 65 and 90 years of age.

In addition, 31 patients suffering either from a cervical (n=12) or pertrochanteric (n=19) fracture were measured on their contralateral femur 15 to 30 days after the fracture event. The mean calculated BMD values were, depending on the measured area, from 14% to 21% lower than those reported for age-matched controls (z-score from -1.11 to -0.65). A fracture threshold was determined for each site from this population and the elderly controls. The best discrimination between patients and controls was obtained at the femoral neck site, with a value of 0.57 g/cm² providing a specificity of 69% with a sensitivity of 75%.

In conclusion, bone mineral content of the proximal femur can be measured with an acceptable precision by dual-energy X-ray absorptiometry. In elderly people, this site appears more suitable than the lumbar spine for the detection of age-related bone loss. Bone mineral density appears to be one major determinant in the causation of hip fracture.

Keywords: Hip fracture; Bone mineral density; Osteoporosis; Bone mass measurement; Dual-energy X-ray absorptiometry

Introduction

In spite of the importance of hip fracture as a major health problem [1, 2, 3] bone mineral content of the proximal femur has been less studied than in the lumbar spine [4, 5, 6] for technical reasons. Densitometers used in the years 1980-1988 functioned with an isotopic source, usually gadolinium 153 which provided a number of photons 500 to 1000 times lower than the X-ray tubes now in more recent devices. This technical improvement allows the performance of quick and precise measurements with a better image resolution [7, 8]. This technique should be promising in the investigation of bone mineral density (BMD) in a complex structure such as the proximal part of the femur.
Because femoral fractures affect mainly elderly women, this study addresses the question of the femoral bone mineral decrease in a population comprising a large group of women older than 65 years. A comparison was made between the age-related changes in the BMD of the femoral sites and in the spine in a sample of elderly women. In an attempt to determine the preferential femoral region which must be taken into account for clinical use and longitudinal follow-up, we have compared the sensitivity and specificity of the BMD measurements for any investigated region of the proximal femoral site by comparing data obtained in patients who had a recent hip fracture with age-matched controls.

**Materials and Methods**

**Bone Densitometry**

Bone mineral density measurements were performed on a densitometer (Hologic QDR-1000®). The area of interest in the lumbar spine measurement was L2–L3–L4. At the femoral site, four regions were measured: the femoral neck, the trochanteric, intertrochanteric and Ward's triangle regions. The total region bone density (which is the mean density of the trochanteric, intertrochanteric and neck areas) was also calculated. The software provided by the manufacturer allowed anatomical separations as shown in Fig. 1. The lower limit of the intertrochanteric region had been chosen 10 lines under the lesser trochanter. The Ward’s triangle area was defined as the area of lowest bone density and not of the actual anatomic Ward’s triangle region; this region was automatically searched for by the software. The results were expressed in g/cm². The mean of the results obtained with right and left femurs was used for the age independence evaluation of the femoral BMD. For all patients with hip fracture, the unfractured contralateral femur was scanned.

**Normal Subjects**

BMD was measured in 133 normal women (mean age 63.5 ± 17 years; range 21–97); 125 of them (69 age 21–65, and 56 age 65–97) also had a lumbar spine measurement. None of them had any previous history of bone disease or any condition or therapy known to affect bone mass. Elderly women (>65 years) were recruited from several retirement homes in Lyon and its surroundings. Metabolic bone disease was excluded in elderly women by means of questionnaire and calcium chemistry test. Young normal controls (29–65 years old) were healthy members of the staff of the hospital and outpatients with benign disease unrelated to bone metabolism who volunteered for the study. In order to calculate the coefficient of variation of the BMD measurement (precision) with repositioning, five healthy subjects, 2 men and 3 women, 40.6 ± 15.6 years old (range 24–59) had 22 measurements of one or both hips (2–6 measurements by subject); in addition, 8 elderly women, 69.6 ± 9.7 years old (range 60–83) had three measurements of one hip.

**Fractured Patients**

Thirty-one women (81.5 ± 7.6 years old) with fractures of the proximal femur were measured. The hip fracture population consisted of all consecutive patients who fractured within a one-year period in six of these retirement homes. The hip fractures were classified as either “cervical” (12 women) or “intertrochanteric” (19 women) on the basis of radiographic and surgical findings. The mean interval between hip fracture and the BMD measurements was 23 days (range 10–40 days). Of the 31 fractured women 5 were measured 14 days to 3 months before the fracture event, as part of a prospective follow-up of elderly women.

**Statistical Analysis**

The least square method was used to perform linear regressions of the BMD measurements with age. The distribution of the bone mineral density values was found to be gaussian. Correlations were calculated between lumbar spine and femoral BMD measurements in the 125 women who were divided into two groups.