Acta Orthop Scand 1988;59(1):19–23

Bone mass in women with hip fracture

Staffan A. V. Eriksson and Torulf L. Widhe

The bone mineral density was determined by dual-photon absorptiometry on the proximal femur in 32 women with femoral neck fractures, 30 with trochanteric fractures, 39 with a fracture elsewhere than the hip, and 16 premenopausal healthy women. Single-photon absorptiometry was performed at two sites on the radius. The bone mineral density in the neck and intertrochanteric area was greater in the women with femoral neck fractures than in those with trochanteric fractures. The bone mineral distribution in the proximal femur was essentially the same for the femoral neck fracture group as for the reference group of healthy women. Neither the Singh index, determined in radiographs, nor the measurements on the radius by single photon absorptiometry provided a reliable estimate of the bone mineral density in the proximal femur

The incidence of hip fractures increases exponentially with age after 50, and after the menopause the bone mass decreases by at least 1 per cent a year (Mazess and Cameron 1974). The reduction in bone mass with age seems to be an important cause of the increasing frequency of hip fracture in the elderly. However, earlier studies provide no consistent evidence of a greater degree of osteoporosis among women with hip fractures than among normal women without such fractures (Riggs et al. 1982, Dretakis et al. 1983).

Dual photon absorptiometry permits measurements of the bone mineral density (BMD) in various parts of the upper femur (Dunn et al. 1980). We have used this technique in postmenopausal women either with hip fracture or with other types of fragility fracture. Dual photon absorptiometry was also used for studies of the BMD in the radius, and the Singh index was used for estimating the BMD of the proximal femur.

Patients and methods

The material for this study included 32 women with a femoral neck fracture and 30 with a trochanteric fracture. All of them were operated on within 3 days of admission to the hospital. A control group consisted of 39 postmenopausal women who had sustained a fracture at a site other than the proximal femur. The mean age, height, and weight of the femoral neck fracture group were 69 years, 61 kg, and 163 cm. The corresponding values for the trochanteric fracture group were 74 years, 55 kg, and 159 cm, and for the control fracture group 70 years, 63 kg, and 164 cm. Sixteen healthy premenopausal women aged 35 to 50 years with no history of fracture and assumed to have a normal skeleton served as a reference group. The patients were admitted to the study in consecutive order. Only patients with a unilateral hip fracture and no previous fracture or disease of the hip were accepted. Patients with pathologic fractures or neurologic disorders were excluded. All the patients had sustained their fracture through stumbling or slipping.

Dual photon absorptiometry. The proximal femur of the unfractured hip was measured by dual photon absorptiometry using the isotope gadolineum-153, which has two energy peaks, namely, 44 and 100 keV. Two energy levels enable the bone mineral density to be calculated with a minimum of interference from the surrounding soft tissues (Wahner et al. 1985). The apparatus used was a Lunar DP3. With the patient supine, the hip was positioned with a slight inward ro-

Karolinska Institute Department of Orthopedics, S-141 86 Huddinge, Sweden

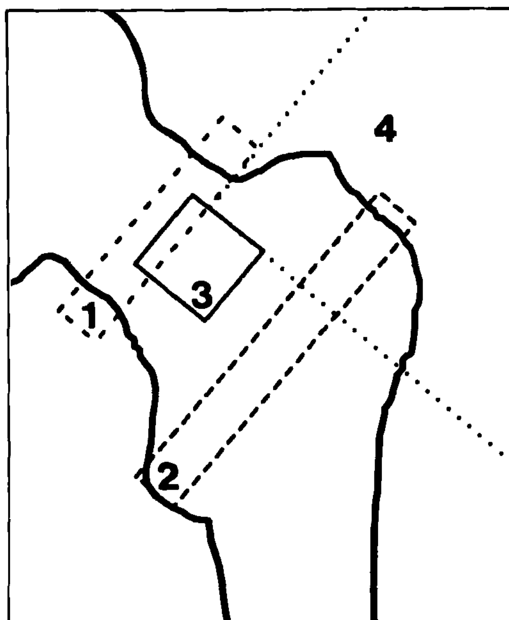


Figure 1. The areas in the proximal femur where the bone mineral density was measured by dual photon absorptiometry. 1 neck area, 2 intertrochanteric area, 3 Ward's triangle and 4 trochanteric area.

tation in order to place the femoral neck parallel to the measuring table and perpendicular to the scanning beam. Rectilinear scanning of the proximal femur was performed with the narrow gamma beam in 2.5 mm steps. The bone mineral density (BMD), which was expressed in grams per square centimeter, was determined at the following four sites (Figure 1): 1) The *neck area*: an area 10-mm wide just medial to the trochanteric area and perpendicular to the femoral neck. 2) The *intertrochanteric area*: an area of the same width parallel to the neck area and located between the lesser and greater trochanters. 3) *Wards triangle*: an area with the lowest absorption in the neck. 4) The *trochanteric area*: an area of the greater trochanter.

The first two sites were delineated individually to include the region where most fractures in the proximal femur are located, whereas the third and fourth areas were automatically defined by the computer software supplied with the apparatus.

Single photon absorptiometry. The BMD of the distal radius at a site just proximal to the bifurcation of the radius and ulna and the shaft, 8 cm from the tip of the ulna styloid process of the nondominant hand, was measured by single photon absorptiometry using the isotope iodine-125. The apparatus was a Lunar SP2. The bone mineral content was expressed in grams per centimeter.

All the measurements were performed within 10 days after the accident.

Singh index. The Singh index (Singh et al. 1970) was determined for the patients with hip fractures. The investigator, who was one of the authors, was unaware of the state of fracture.

Serum biochemistry. The concentrations of calcium, phosphate, alkaline phosphatase, calcitonin, and PTH were determined as soon as possible after admission to the hospital and before the operation.

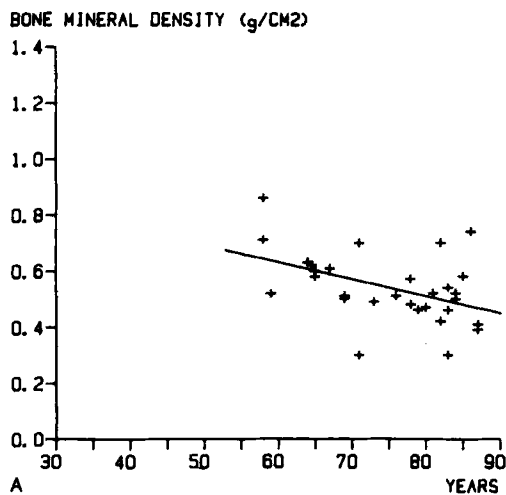
As regards the blood chemistry, there were no differences between the three groups. The calcitonin and PTH concentrations were within normal limits in all the patients. Alkaline phosphatase was moderately increased in a few patients, but their serum calcium and phosphate levels were not consistent with the presence of osteomalacia.

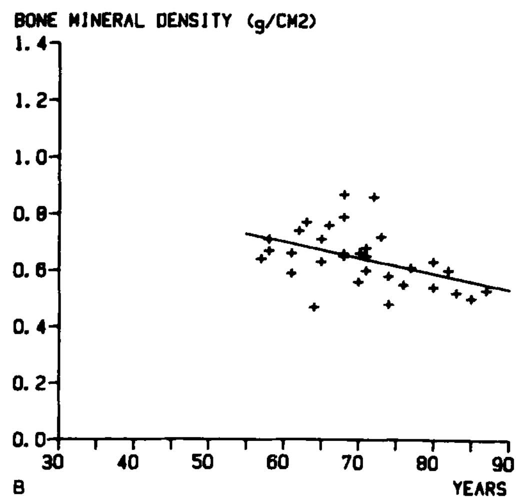
Statistics. The linear regression and the correlation coefficient were calculated for the bone mineral content or density in relation to the age of the subjects. Student's *t*-test of paired observations was used for examining the difference in BMD between the three groups, which were matched for age. Student's *t*-test of unpaired observations was used for testing the differences in BMD between the groups.

Results

There was an annual bone mineral loss of about 1 per cent in the fracture groups (Figure 2). The loss was roughly the same for the reference group of healthy premenopausal women as for the postmenopausal women; this indicates that there was no acceleration of bone loss after the menopause. From the small slope of the regression line for BMD on age, it is evident that the statistical analysis of the whole material and the age-matched material yielded similar results.

The trochanteric fracture group had a lower BMD value in both the neck and the intertrochanteric area than either the neck fracture or the control groups (Table 1). In neither the neck nor the intertrochanteric area did these latter two groups differ in respect to the BMD.





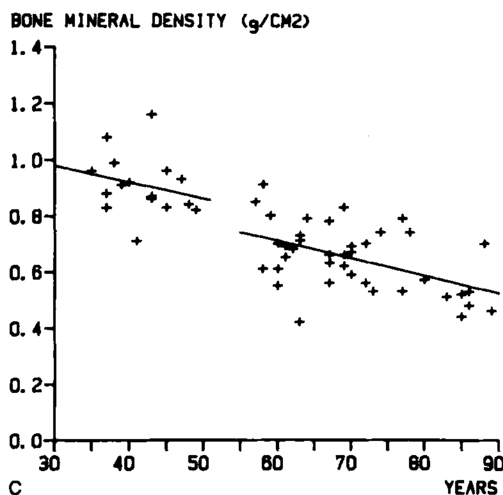


Figure 2. Regression of bone mineral density for the neck area on age.
A. Trochanteric fracture group; Y = 0.966−0.00607X,
B. Femoral neck fracture group; Y = 1.038−0.00562X,
C. Fracture control group (over the age of 55 years); Y = 1.081−0.00620X. Reference group (below the age of 50 years); Y = 1.156−0.00590X.

Intragroup comparisons of the neck and intertrochanteric areas suggested an inverse relationship between the two types of fracture (Table 2). In the femoral neck group, the BMD was lower for the neck than for the intertrochanteric area, whereas in the trochanteric group the opposite relationship was found, though not at the level of significance.

A BMD value equal to or greater than 0.6 g/cm^2 in the intertrochanteric area was recorded in 27 of the 32 women with a femoral neck fracture, but in only 6 of the 30 women with a trochanteric fracture. In the premenopausal group, the BMD in the proximal femur was higher than in the other groups (Table 2, Figure 2). However, at least 6 of the 16 healthy women below aged 50 had a BMD value in the neck area below the highest values recorded for the two hip fracture groups. According to the results of single photon absorptiometry of the radius shaft, the annual decrease in bone mass was more than twice as great in the trochanteric fracture group (1.3 per cent) than it was in the cervical group (0.5 per cent) (Figure 3). Moreover, the decrease was greater in the control fracture group (1.0 per cent) than in the femoral neck fracture patients.

Table 1. Comparison (*P*-values) between the three fracture groups with respect to the bone mineral density at the four measuring sites in the proximal femur (age-matched). T trochanteric, N neck, C Control

	Area			
	Neck	Ward's triangle	Troch.	Intertroch.
N vs T (19)	<0.05	<0.01	<0.01	<0.01
C vs N (23)	NS	NS	NS	NS
C vs T (17)	<0.01	<0.01	<0.05	<0.01

Table 2. Bone mineral density at the four measuring sites in the proximal femur. All patients included. T trochanteric, N neck, C control, R reference. Values are mean (SD).

	Area			
	Neck	Ward's triangle	Troch.	Intertroch.
T	0.54 (0.12)	0.37 (0.13)	0.44 (0.11)	0.48 (0.17)
N	0.64 (0.10)	0.50 (0.10)	0.58 (0.10)	0.71 (0.13)
C	0.65 (0.12)	0.48 (0.13)	0.54 (0.13)	0.66 (0.20)
R	0.91 (0.11)	0.80 (0.11)	0.73 (0.11)	0.97 (0.11)

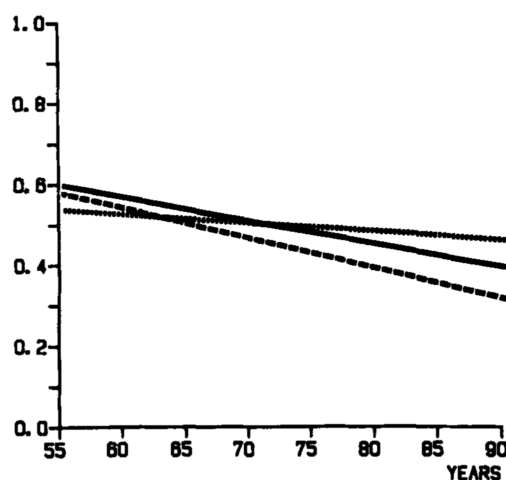


Figure 3. Regression of the bone mineral content of the radius shaft on age.
Trochanteric fracture group, Y = 0.971–0.00724X,
Femoral neck fracture group, Y = 0.665–0.00230X,
Fracture control group (over the age of 55 years). Y = 0.909–0.00576X.

Table 3. Correlation between bone mineral density at the four measuring sites in the proximal femur and bone mineral content/width at two measuring sites in the radius. All the patients included. *P <0.05; **P<0.01; ***P<0.001. T Trochanteric, N neck, C control

	Shaft of radius			
Area	T	N	C	All
Neck	0.58**	0.44*	0.53**	0.59***
Ward	0.67***	0.38*	0.59***	0.62***
Troch.	0.71***	0.51**	0.59***	0.62***
Intertroch.	0.52**	0.44*	0.47**	0.62***

	Distal radius			
Area	T	N	C	All
Neck	0.56**	0.40*	0.14 NS	0.37***
Ward	0.55**	0.44*	0.22 NS	0.40***
Troch.	0.65***	0.48**	0.15 NS	0.37***
Intertroch.	0.52**	0.43*	0.16 NS	0.30**

Table 4. Singh index in relation to the mean bone mineral density in the neck area for the two hip fracture groups. (age-matched). Number of patients in parentheses. T trochanteric, N neck

	Singh index				
	1	2	3	4	5
Trochanteric	–	0.39 (2)	0.54 (12)	0.86 (1)	–
Neck	0.47 (1)	0.61 (2)	0.61 (7)	0.70 (5)	–

The correlations between the BMD values at the various sites of the radius and of the proximal femur were weak (Table 3).

The Singh index was the same for the two hip fracture groups, and there was no correlation between the index and the BMD for the proximal femur (Table 4).

Discussion

The trochanteric fracture patients were about 5 years older than those of the other two fracture groups. A similar difference has been reported by other workers (Dretakis et al. 1983). This difference was taken into account in the analysis of the results. The difference in BMD of the proximal femur between the two types of hip fractures has not been reported in earlier studies in which dual photon absorptiometry was used. Riggs et al. (1982) found no difference between these two types of fracture with respect to bone mineral density in the proximal femur, whereas Bohr and Schaadt (1983) recorded no such difference in neither the neck nor the midshaft femur. This discrepancy may be due to the smaller size of Riggs' material and that Bohr and Schaadt in their analysis used measurements from the femoral neck and midshaft femur (mainly cortical bone) rather than the trochanteric region, as in our study.

In some studies on bilateral noncontemporary fractures of the upper femur, a symmetric location of the fractures has been common; when the first fracture was trochanteric, the second one was very often of the same type (Alffram 1964, Dretakis et al. 1981, Finsen et al. 1986). This tendency towards symmetry points to an endogenous etiologic factor in the location of fractures of the upper femur.

In most studies of the relationship between osteoporosis and fragility fractures, one measuring site is chosen as being representative of the bone mineral content for another part of the skeleton or for the whole bone mass (Wahner et al. 1977, Wootton et al. 1979). Close correlations between skeletal sites have been reported. In an analysis of the relationship between the BMD in

the radius, ulna, and femur in 24 skeletons by single photon absorptiometry, Wilson (1977) found the closest correlation to be that between the femoral neck and the midshaft radius ($r = 0.86$). Moreover, Aitken et al. (1974) reported a much better correlation between sites in the radius and the femur in 21 female cadavers than the correlation found in our study (Table 3). Measurements on patients would presumably be less accurate than direct measurements on stripped skeletons. Probably the most important factor accounting for the observed weak correlation is a real difference in the BMD of different parts of the skeleton in elderly women, because there is evidence that the change in the rate of bone loss with age differs according to site (Riggs et al. 1982, Härmä et al. 1985).

The Singh index did not prove to be a reliable index of the BMD in the proximal femur. Our results confirm the observation by Bohr and Schaadt (1983) that there is no correlation between the BMD of the femoral neck and the Singh index.

References

Aitken J M, Smith C B, Horton P W, Clark D L, Boyd J F, Smith D A. The interrelationships between bone mineral at different skeletal sites in male and female cadavera. J Bone Joint Surg (Br) 1974;56(2):370–5.

Alffram P A. An epidemiologic study of cervical and trochanteric fractures of the femur in an urban population. Acta Orthop Scand1964;(Suppl 65):1–57.

Bohr H, Schaadt O. Bone mineral content of femoral bone and the lumbar spine measured in women with fracture of the femoral neck by dual photon absorptiometry. Clin Orthop 1983;(179):240–5.

Dretakis E, Kritsikis N, Economou K, Christodoulou N. Bilateral non contemporary fractures of the proximal femur. Acta Orthop Scand 1981;52(2):227–9.

Dretakis E K, Christodoulou N A. Significance of endogenic factors in the location of fractures of the proximal femur. Acta Orthop Scand 1983;54(2):198–203.

Dunn W L, Wahner H W, Riggs B L. Measurement of bone mineral content in human vertebrae and hip by dual photon absorptiometry. Radiology 1980;136(2): 485–7.

Finsen V, Benum P. The second hip fracture. An epidemiologic study. Acta Orthop Scand 1986;57(5): 431–3.

Härmä M, Karjalainen P, Hoikka V, Alhava E. Bone density in women with spinal and hip fractures. Acta Orthop Scand 1985;56(5):380–5.

Mazess R B, Cameron J R. Bone mineral content in normal U.S. whites. In: Intern Conf Bone Mineral Measurement, US Dept. HEW, Washington 1974:228–38.

Riggs B L, Wahner H W, Seeman E, Offord K P, Dunn W L, Mazess R B, Johnson K A, Melton L J. Changes in bone mineral density of the proximal femur and spine with aging. Differences between the postmenopausal and senile osteoporosis syndromes. J Clin Invest 1982;70(4):716–23.

Singh M, Nagrath A R, Maini P S. Changes in trabecular pattern of the upper end of the femur as an index of osteoporosis. J Bone Joint Surg (Am) 1970;52(3): 457–67.

Wahner H W, Riggs B L, Beabout J W. Diagnosis of osteoporosis: usefulness of photon absorptiometry at the radius. J Nucl Med 1977;18(5):432–7.

Wahner H W, Dunn W L, Mazess R B, Towsley M, Lindsay R, Markhard L, Dempster D. Dual photon Gd-153 absorptiometry of bone. Radiology 1985; 156(1):203–6.

Wilson C R. Bone mineral content of the femoral neck and spine versus the radius or ulna. J Bone Joint Surg (Am) 1977;59(5):665–9.

Wootton R, Brereton P J, Clark M B, Hesp R, Hodkinson H M, Klenerman L, Reeve J, Slavin G, Tellez-Yudilevich M. Fractured neck of femur in the elderly: an attempt to identify patients at risk. Clin Sci 1979;57(1):93–101.

Acknowledgements

Department of Hospital Physics, Huddinge University Hospital.