Decreased broadband ultrasound attenuation of the calcaneus in women with fragility fracture

85 Colles' and hip fracture cases versus 77 normal women

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The broadband ultrasound attenuation (BUA) of the right calcaneus was measured in 49 women with Colles' fracture, in 36 women with hip fracture, and in 77 normal women. All were postmenopausal, and the fractures were all of fragility type. BUA correlated with age only in the normals. BUA distinguished between the fracture cases with sensitivities of 97 percent and 70 percent and specificities of 72 percent and 92 percent at 61 dB/MHz and 51 dB/MHz, respectively. The women with hip fracture had lower BUA than those with Colles' fracture. For screening purposes, BUA below 51 dB/MHz may arouse suspicion of a fracture risk, notably if other factors such as a tendency to fall, dietary and other habits, inactive lifestyles and early menopause are present.

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The measurement of the broadband ultrasound attenuation (BUA) or the ultrasound (US) velocity within a bone is a non-invasive, radiation-free, rapid and inexpensive method which has been used to evaluate osteoporosis (Greenfield et al. 1981, Langton et al. 1984, Heaney et al. 1989, Baran et al. 1991). BUA of the calcaneus correlates with single photon absorptiometry (SPA) of the radius, as well as bone mineral density (BMD) of the lumbar spine and the femur, determined by dual photon absorptiometry (DPA) and dual energy x-ray absorptiometry (DEXA) (Poll et al. 1986, Baran et al. 1988, Rossman et al. 1989, McCloskey et al. 1990b, Eastell et al. 1991). The US techniques evaluate a combination of bone mass and bone architecture which may be a better predictor of fracture risk than BMD (Langton et al. 1984, Heaney et al. 1989, Porter et al. 1990, Truscott 1991).

We have compared BUA of the calcaneus in women with Colles' and hip fractures to the BUA value in normal postmenopausal women.

Patients and methods

After obtaining informed consent, BUA of the calcaneus was determined in 162 postmenopausal women, 49 with Colles' fracture (48–82 years of age), 36 with hip fracture (59–92 years of age), and 77 without fracture, i.e., the control (normal) group (41–87 years of age). All were fragility type fractures, resulting from a low energy fall from standing position or less. The measurements were carried out at the right calcaneus, not more than 10 days from the time of the accident.

The control cases were derived from the early 251 healthy asymptomatic postmenopausal women examined by the first author during a program for the determination of normal BUA values in the female population in Crete. They were taken from the population registers of our hospital catchment area. They had no history of a previous fragility fracture and were assessed by medical history and physical examination. There was no disease or condition known to affect the bone status. Each woman in the control group had a lateral calcaneus radiograph taken, and most also had lateral spine radiographs. There was no evidence of osteoporotic vertebrae, and the trabecular pattern of the calcaneus was Type V or IV according to the method of Jhamaria et al. (1983), which correlates with Singh's index and with bone density (Zhu 1990). In 5 cases, 71–87 years of age, the trabecular pattern was Type III (Borderline) and was considered normal.

The BUA measurement was performed in all our subjects by means of a computer-controlled bone analyzer UBA-575 (Walker Sonix, U.S.A.). The system has an emitting US transducer and a receiving

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Table 1. The cases in each group with BUA below 61 dB/MHz and below 51 dB/MHz

Group	n	BUA < 61	BUA < 51
Colles' fractures	49	47	29
Hip fractures	36	36	31
Normal	77	22	6

Table 2. The age and the BUA (db/MHz) in the fracture and normal groups. Mean *SD*

	n	Age		BUA	
Colles' fractures	49	65	*10*	48	*8*
Hip fractures	36	77	9	39	*10*
Normal	77	62	*10*	66	*10*

transducer incorporated in a tank of water. In the beginning a reference measurement is made from 25 samples of different frequencies in the range of 0.2–0.6 MHz, without the heel being immersed in the tank. Then the foot is positioned in the water bath and the ultrasonic transducers scan the calcaneus region in 1.6 increments. The computer compares the signal obtained by this scan with the reference signal, and the difference between these 2, gives the frequency dependence of attenuation in the calcaneus. The slope of the attenuation-frequency curve is expressed in dB/MHz and is referred to as the BUA value.

Short-term reproducibility was assessed in our previous study by recording 5 independent measurements of BUA in each of 5 women. The coefficient of variation was 3.8 ± 1.4 percent (Damilakis et al. 1992).

Statistics

Data are presented as means ± standard deviation. Linear regression analysis was used to determine the relation between BUA and age. The mean BUA in the cases with Colles' fracture, in the cases with hip fracture, and in the normal cases were compared by the method of one-way analysis of variance. Analysis of covariance was carried out to compare the differences in BUA between the above groups of cases, without the dependence on the age. The sensitivity and the specificity were determined as follows:

sensitivity = cases with fracture and BUA < cut-off point / cases with fracture × 100,

specificity = normal cases and BUA > cut-off point / total normal cases × 100.

Results

In 83 out of 85 cases with Colles' or hip fracture, the BUA values were below 61 dB/MHz (Table 1). In 31 out of 36 cases with hip fracture the BUA values were lower than 51 dB/MHz. The correlation between BUA and age in the 2 fracture groups was not significant (Table 2; r –0.200 in Colles' fracture and –0.241 in hip fracture, $P > 0.15$). In the normal group, a significant negative correlation between BUA and age was found (r –0.479, $P < 0.0001$). With the dependent variable BUA and the independent variable age, the equation of the regression line was BUA = 90.38 – 0.483 × age (slope –0.483, $P < 0.0001$, SEE 9.33).

The differences between the mean BUA in the normal and the Colles' fracture groups, in the normal and hip fracture groups, and between the 2 fracture groups were significant ($P < 0.0001$). Analysis of covariance was carried out to compare the differences in BUA between the 3 groups without the dependence on the age. It was found that the differences remained significant ($P < 0.0001$).

Considering as cut-off point the BUA value 61 dB/MHz, the sensitivity was 97 percent and the specificity 72 percent. At BUA 51 dB/MHz, the sensitivity and the specificity were 70 and 92 percent, respectively. Using age-matched controls, at BUA 61 dB/MHz the sensitivity and specificity were 97 and 75 percent, respectively. At BUA 51 dB/MHz they were 70 and 90 percent, respectively.

Discussion

The technique of BUA was first introduced by Langton et al. (1984). Despite the fact that BUA is influenced not only by bone density but also by structural parameters, BUA provides a significant correlation with SPA, DPA, DEXA and quantitative computed tomography (QCT) measurements (McKelvie et al. 1989, Rossman et al. 1989, McCloskey et al. 1990b, Agren et al. 1991). Wasnich et al. (1985) reported that the calcaneus BMD (by SPA) was as effective as the lumbar spine or radius BMD for prediction of fractures. McCloskey et al. (1990a) examining the relationship between BUA of the os calcis in vitro and its bone mineral density measured by QCT and by physical density, concluded that BUA provides a rapid and reproducible index of skeletal status.

The correlation between BUA and age in our normal women represented about a 30 percent decrease in BUA between the ages of 41 and 87 years. There has been reported, however, a 10 percent decrease in

the density of the calcaneus in women of 40–75 years (Roberts et al. 1982). The reason for this difference may be that BUA reflects both density and structure.

It has been stated that the BUA of the calcaneus is a sensitive and specific discriminator of osteopenia. At 63 dB/MHz, the sensitivity and specificity of BUA for decreased bone mineral density with or without fractures were 76 percent (Agren et al. 1991). In our study the sensitivity and specificity for osteoporotic fractures were 97 and 72 percent, respectively, at BUA 61 dB/MHz, and 70 and 92 percent, respectively, at BUA 51 dB/MHz. Massie et al. (1992), comparing BUA and DEXA in 32 women with hip fracture and in controls, tested the ability of each technique to distinguish between the 2 groups. They showed that, at 80 percent sensitivity, the specificity was 82 percent for BUA and 74 percent for DEXA in women with a fracture of the neck of the femur. This suggests that BUA is a better discriminator than DEXA between elderly women with hip fracture and controls.

The mean BUA in the hip fracture group was lower than the mean BUA in the Colles' fracture group and in the normal group, independently of the age. This indicates that the women who sustained a hip fracture were more osteoporotic than those with a Colles' fracture. In a previous study lower BUA values were reported in postmenopausal women with hip fracture (Baran et al. 1988). However, the number of cases was smaller (10) than in ours, and the measurements were carried out at an interval between 2 weeks to 1 year from the time of fracture. It is possible that the late BUA measurement in these patients affects the BUA value of the calcaneus. In another study higher BUA values (54 dB/MHz) were reported in 20 osteoporotic women with fracture, but it included 16 cases with spinal and only 4 with femoral neck fractures (Agren et al. 1991).

It is worth noting that in 31 out of the 36 women with hip fracture, BUA was lower than 51 dB/MHz. Although the sample sizes of the patients with fragility fracture in the present study do not allow the establishment of thresholds for fracture, there is evidence that BUA value below 51 dB/MHz may arouse suspicion of a fracture risk in the population screened, if other factors such as a tendency to fall, dietary or other habits, inactive lifestyles and early menopause are present.

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