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THE BONE MINERAL CONTENT IN THE FOREARM OF WOMEN WITH COLLES' FRACTURE

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Buhr & Cooke (1959) pointed out the rather specific epidemiological pattern of fracture of the distal end of the forearm. This pattern was studied in greater detail by Alffram & Bauer (1962) and it was demonstrated that the risk of fracture in women over the age of 40 increased dramatically. Later, Alffram (1964) demonstrated that women with fracture of the upper end of the femur also more frequently than could be expected from the incidence of the population at risk had sustained fracture of the distal end of the forearm.

Bauer (1960) interpreted data on fracture incidences and suggested that fracture of the distal end of the forearm is an early symptom and fracture of the upper end of the femur a late symptom of disturbed skeletal metabolism.

The objective of the present study was to compare the bone mineral content of the forearm in women with Colles' fracture and in a control sample of women without fracture.

MATERIAL

Sixty-four women were selected who had sustained a fracture of the distal end of the forearm (Colles' fracture). Only women in whom the fracture was caused by falling from the standing position or other lesser trauma were included. In addition 64 women without fracture were measured. The ages of the fracture and control cases were 63.6 ± 10.7 and 63.5 ± 11.1, respectively. All except 5 fracture cases and 6 controls were post-menopausal.

No women were included who had previous fracture or other pathological condition in the upper limbs including the shoulders, who had undergone gastric

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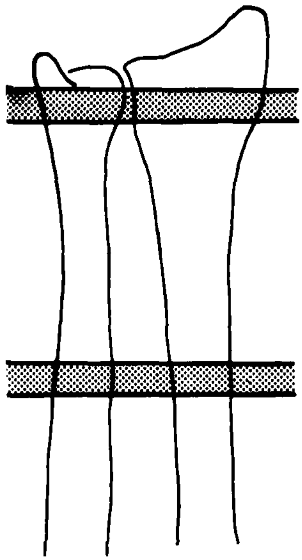

Figure 1. The sites of the rectilinear scans.

surgery or who had kidney disease, liver dysfunction, intestinal dysfunction, alcoholism or other conditions known or suspected to be related to bone mineral loss.

In the control cases the bone mineral content was measured in both forearms. In the fracture cases the bone mineral content was measured within a week of the occurrence of fracture. In 19 cases both forearms were measured, which required anaesthesia; in the remaining cases only the uninjured forearm was measured.

METHODS

Vital Statistics

Height, weight, age at menarche, age at menopause and parity were recorded.

Bone Mineral Content

The bone mineral content was measured by the method of gamma absorptiometry. The measuring device has been described previously (Nilsson & Westlin 1972, Westlin 1974). Two rectilinear scans were made across the ulna and the radius at 1 cm—*distal* measuring site—and 6 cm—*proximal* measuring site—from the distal end of the ulna located by palpation (Figure 1). The results were expressed in mg per cm^2 and represent the average thickness of bone mineral in the pathway of the beam in the radius plus the ulna.

Width

As well as the digital representation of the mineral content in the forearm, the width of the ulna and the radius facing the beam and the width of the marrow cavity can be measured on a graphical tracing of the scan (Westlin 1974). From the tracings the total width of the radius and the ulna, the total width of the marrow cavities of the two bones and the total cortical thickness of the two bones were calculated.

Size and Force

The length of the ulna from the tip of the olecranon to the distal end, and the maximum circumference of the forearm in the relaxed position were measured. Also, the force of the hand grip was measured—the women were asked to compress a rubber bulb and the pressure in kg/cm² was recorded by a manometer; the average of 3 attempts was used.

RESULTS

The height was slightly and almost significantly greater in the fracture cases; there was no significant difference in weight (Table 1). Of the GOB variables only parity differed slightly between the fractures and controls; the difference was not significant.

The bone mineral content was reduced by about 7 per cent in the fracture cases as compared to the control cases with the same reduction in both measuring sites. However, the difference was significant only in the proximal measuring site on the shafts of the two bones (Table 2).

From the total (subperiostal) width and the width of the marrow cavities of the two bones the combined cortical thickness of the bones was calculated (Table 2). The cortical thickness was reduced by about 13 per cent. This reduction may explain completely the reduction in bone mineral content and when the cortical thickness was corrected for

Table 1. Vital statistics.

Variable	Fracture		Control		P*
	No.	Av. ± SD	No.	Av. ± SD	
Age	64	63.5 ± 10.7	64	63.4 ± 11.1	$0.9 > P > 0.8$
Height (cm)	57	163.7 ± 6.2	54	162.1 ± 6.2	$0.05 > P > 0.02$
Weight (kg)	60	65.0 ± 10.4	61	66.3 ± 10.1	$0.9 > P > 0.8$
Menarche age	64	14.1 ± 1.4	62	14.4 ± 1.7	$0.3 > P > 0.2$
Menopausal age	58	48.6 ± 5.8	55	49.1 ± 4.5	$0.7 > P > 0.6$
Years after menopause	58	16.9 ± 9.8	55	17.0 ± 10.2	$0.8 > P > 0.9$
Parity	63	1.41 ± 1.27	62	1.85 ± 1.56	$0.1 > P > 0.05$

* T-test of pairs (pair = women with fractures and age-matched controls).

Table 2. Mineral content and bone widths.

Variable	Fracture No.	Fracture Av. ± SD	Control No.	Control Av. ± SD	P*
Mineral content distal (mg/cm^2)	64	231 ± 70	64	249 ± 74	$0.2 > P > 0.1$
Mineral content prox. (mg/cm^2)	64	430 ± 77	64	464 ± 81	$0.01 > P > 0.001$
Total width prox. (mm)	64	28.9 ± 2.2	64	29.2 ± 2.0	$0.6 > P > 0.5$
Marrow width prox. (mm)	64	16.3 ± 2.3	64	15.7 ± 2.4	$0.3 > P > 0.2$
Cortical thickness prox. (mm)	64	12.6 ± 1.9	64	13.4 ± 1.7	$0.01 > P > 0.001$
Total width distal (mm)	64	43.2 ± 5.5	64	43.7 ± 3.4	$0.8 > P > 0.7$

* T-test of pairs (pair = women with fractures and age-matched controls).

(covariance analysis with cortical thickness as the covariant factor) there was no longer any difference between the bone mineral content in the proximal measuring sites.

Finally, the size and the force measurements (Table 3) indicate a decreased circumference of the forearm of the fracture cases as compared to the control cases. The small difference in force of the hand was, however, not significant.

DISCUSSION

From the data of the control women it could be demonstrated that there is a non-systematic left-right variation which is relatively more marked in the distal measuring site (Figure 2). It must, therefore, be assumed that in women without fracture the bone mineral mass of the left and the right forearms do not differ. Thirty-two of the fracture cases had injured their left arm; in these cases the uninjured right arm was measured and assumed to represent the bone mineral mass of the forearms of these patients. In the remaining 32 patients the opposite

Table 3. Size and force of the forearms.

Variable	Fracture No.	Fracture Av. ± SD	Control No.	Control Av. ± SD	P*
Ulnar length (cm)	56	25.4 ± 1.5	64	25.6 ± 1.1	$0.4 > P > 0.3$
Arm circumference (cm)	56	24.5 ± 2.1	64	25.4 ± 1.9	$0.02 > P > 0.01$
Force kg/cm^2	55	0.53 ± 0.17	64	0.55 ± 0.20	$0.4 > P > 0.3$

* T-test of pairs (pair = women with fractures and age-matched controls).

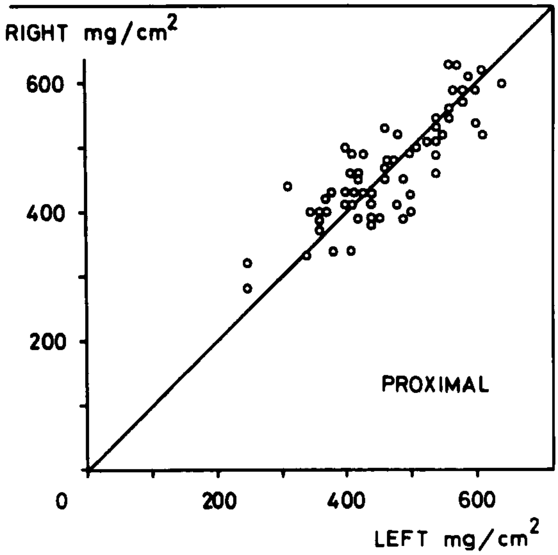

Figure 2 a.

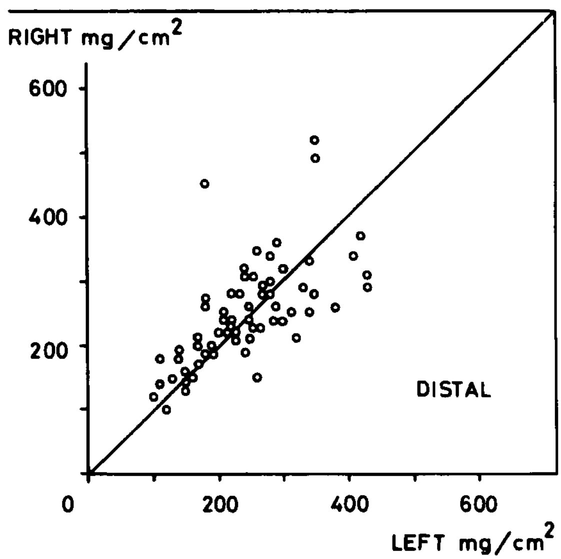

Figure 2 b.

Figure 2. The relationships between the bone mineral contents of left and right forearms in control women.

Table 4. Mineral mass of the contralateral arm in fracture cases (mg/cm^2).

	Left		Right	
	No.	Av.±SD	No.	Av.±SD
Proximal	32	434±73	32	426±82
Distal	32	236±74	32	226±66

was the case. A comparison of right-sided and left-sided measurements is demonstrated in Table 4. There was no difference between left arms and right arms. In addition, measurements were available from the day of the fracture in 19 of the patients in whom the proximal site of the fractured forearm was measured under anaesthesia. The value (443 ± 108 mg/cm^2) did not differ significantly from the values of the uninjured forearms of the fracture cases.

It must, therefore, be assumed that the value of bone mineral content of the uninjured forearm is a fairly accurate parameter of the injured arm and that there is no significant difference between the two.

A difference in mineral mass between the bones of injured and uninjured women may be due to a difference in size, an increased porosity, a reduced mineralization, and—in diaphyseal bone—to differences in the width of marrow cavities. With regard to the size of the bones it must be concluded from our data—the widths of the bones on the two measuring sites and the length of the ulna—that the bones of the forearm are of the same size in women with and without Colles' fracture.

It should be stressed that the measurements of the cortical thickness, as calculated from the widths obtained from the tracings of the scans, are not very accurate although they may be more accurate than measurements from radiographs on this site (Westlin 1974).

Nordin (1966) demonstrated that the metacarpal index, based on measurements from radiograms of the second metacarpal, was lower in women with Colles' fracture than in normal controls. This finding is confirmed in the present study; also in the fractured bone itself, the radius, there is evidence of thinning of the cortices and in fact the significant reduction of bone mineral content in the shafts of the radius and the ulna can be completely explained by the cortical thinning. The probable difference between fracture and control cases in bone mineral content in the distal measuring site, however, can probably only be explained by an increased porosity.

Is the difference in bone mineral mass demonstrated in this study sufficient to cause an increased risk of fracture? The difference amounted to no more than 7 per cent and was not even significant at the fracture site. Data, experimental as well as clinical, support the concept that a small loss of bone mineral may cause a disproportionately greater loss of bone strength (Voss et al. 1961, Beck & Dunbar 1967, Nilsson & Smith 1969). From the data of the control women in the present study it can be calculated that during the fifth through the eighth decade of life the average loss of bone is 9–10 per cent per decade. This figure is supported by other data from our laboratory and by other investigators (Oeser & Krokovsky 1963, Meema & Meema 1963, Smith & Rizek 1966 and Garn et al. 1967). Therefore, in relation to the rapid changes with age of the risk for Colles' fracture in women, a loss of 7 per cent translated into years in the fifth or sixth decade of life could be associated with a quadrupling or more of the risk of fracture (Buhr & Cooke 1959, Alffram & Bauer 1962). Ideally, each case of fracture in this study should have been compared to a woman who had been subjected to an adequate trauma like falling to the ground from the standing position, without sustaining a fracture, in analogue with the data of Vose & Lockwood (1965) in their study of the bone mass in individuals with femoral neck fracture. The control group probably contains individuals with the same fracture risk as those of the fracture group with the exception that they have not yet had their fracture. This, also, should be kept in mind when the bone mineral mass of the two sets is compared.

Nilsson (1970) demonstrated that while the femoral neck fracture was associated with spinal osteoporosis (measured as shortening of the trunk) and with weight reduction, fracture of the forearm was not. This is supported by the present study in that there is no significant weight difference, and the fracture cases were on the contrary somewhat taller. On the other hand as far as can be seen from the measurements of the forearm with an intact muscle force and decreased forearm circumference the fracture cases may be somewhat leaner. The same has been demonstrated in alcoholics (Nilsson & Westlin 1973).

The parity observed in the fracture cases was suspiciously low and was caused by an increased number of nulliparous women in the sample. The difference was, however, not significant. When the sample size was doubled including also women with Colles' fracture who were not included in the present study and comparing to the population data of Malmö (Bjerre 1974) the difference remained statistically non-significant. Alffram (1964) could not demonstrate any differences between women with and without femoral neck fracture in this respect.

Otherwise, however, few differences could be demonstrated between the two sets, women with and without Colles' fracture. A 7 per cent loss of bone mineral content mainly due to cortical porosity of the forearm may, however, in the light of the evidence from the literature, result in sufficient change in quality to cause a substantial increase in the risk of fracture.

SUMMARY

The bone mineral content in the forearms was measured by the method of gamma absorptiometry in 64 women with Colles' fracture and 64 age-matched women without fracture. The bone mineral mass was reduced by about 7 per cent in the shafts of the radius and ulna proximal to the fracture and also but not quite significantly in the trabecular structures of the distal end of the forearm, the fracture site. The reduction, although small, may well cause an increased risk of fracture when the rapid change of fracture incidence with age is taken into account.

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