TOTAL AND REGIONAL BONE MINERAL DENSITIES IN WOMEN WITH COLLES' FRACTURES: A COMPARATIVE STUDY WITH NORMAL MATCHED CONTROLS

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ABSTRACT

Total body and regional bone mineral densities (BMDs) were measured in 34 women with past Colles' fracture and 34 age- and sex-matched controls using the Norland XR-26 dual energy X-ray bone densitometer. The results showed that in patients with Colles' fracture affecting the left forearms, the BMD at the ultradistal 2.5 cm region was significantly lower in the right forearm when compared with the left. This difference was not statistically significant among patients with fractures affecting the right or both forearms. The patients were also found to have lower BMDs in the femoral regions (0.600 ± 0.010 g/cm² in patients versus 0.655 ± 0.019 g/cm² in controls), pelvis (0.679 ± 0.009 g/cm² in patients versus 0.728 ± 0.020 g/cm² in controls) and spine (0.710 ± 0.018 g/cm² in patients versus 0.780 ± 0.030 g/cm² in controls) when compared with the controls. No such difference could be demonstrated in the head, trunks or arms. These data suggested that women with past Colles' fracture might be more prone to fractures of spine and femoral regions. Bone mineral densities in the weight-bearing regions, including femur and spine correlated strongly with each other (femoral neck versus lumbar spine, r=0.64, p<0.0001). Sites from the same anatomic regions, namely the femoral regions had highly correlated BMD values (femoral neck versus Ward's triangle, r=0.91, SEE=0.05, p<0.0001), while poorer correlation was found among unrelated regions, such as between left ultradistal forearm and femoral neck (r=0.43, SEE=0.10, p<0.05).

Keywords: Colles' fracture, Southern Chinese, bone mineral density, osteoporosis

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INTRODUCTION

Colles' fracture is a major complication of osteoporosis in Hong Kong. An annual incidence of 10,000 is estimated in the population of 6 million[1-3]. Colles' fracture is generally considered as a manifestation of Type 1 (postmenopausal) osteoporosis[4], in which there is disproportionate and accelerated loss of trabecular bone and hence characteristically occurs at skeletal sites containing large amounts of trabecular bone eg the distal forearm[5]. Type 1 osteoporosis mainly affects women within 25 years of menopause and is believed to result mainly from factors related to oestrogen deficiency[6].

There have been much interest in assessing the importance of trauma versus bone loss in the pathogenesis of Colles' fracture. Although a relationship between fracture and bone mineral density (BMD) in the distal end of the radius is suggested by the data of Nilsson et al[7] and Jensen et al[8], studies of the overall bone mineral mass in patients with Colles' fracture have been inconclusive[8-15]. Bone mineral density measured in the uninjured radius of women with Colles' fracture has been found to be lower in some studies[5,8-10] but not all[11,12]. Measurement of BMD of ultradistal radius (distal 2.5 cm of the radius) has succeeded to detect a threshold level above which Colles' fracture was uncommon and below which fractures become more likely as BMD becomes lower[16].

In attempting to identify any increased risk to bone fracture occurrence in patients having shortly recovered from Colles' fracture, their total body and regional BMDs were evaluated and compared to age- and sex-matched normal controls using dual energy X-ray absorptiometry (DEXA).

MATERIALS AND METHODS

Test Subjects

Thirty-four postmenopausal women with recent Colles' fracture gave informed consent and volunteered for the study. Their mean age was 60.5 (range from 44 to 71) years. Subjects who had any medical disorder associated with metabolic diseases, who were taking medication or drugs known to affect mineral metabolism, or who had habits of smoking or drinking alcohol were identified by questionnaire and excluded from the study. The patients were studied within an average of 9.4 (ranged from 7 to 18) months after their fracture, and have all their casts removed. Thirty-four age-matched healthy women were chosen from hospital staff as normal controls in the study (Table I). The studies were carried out in December 1989.

Bone Mineral Measurement

Total body and regional BMDs were measured by the Norland XR-26 X-ray bone densitometer (Fort Atkinson, WI) which is operated by the principle of DEXA and has been described in details by the author elsewhere[17]. The accuracy and precision of BMD measurements, as documented by repeated in vitro measurements on dedicated step phantom by Kotzi et al[18],

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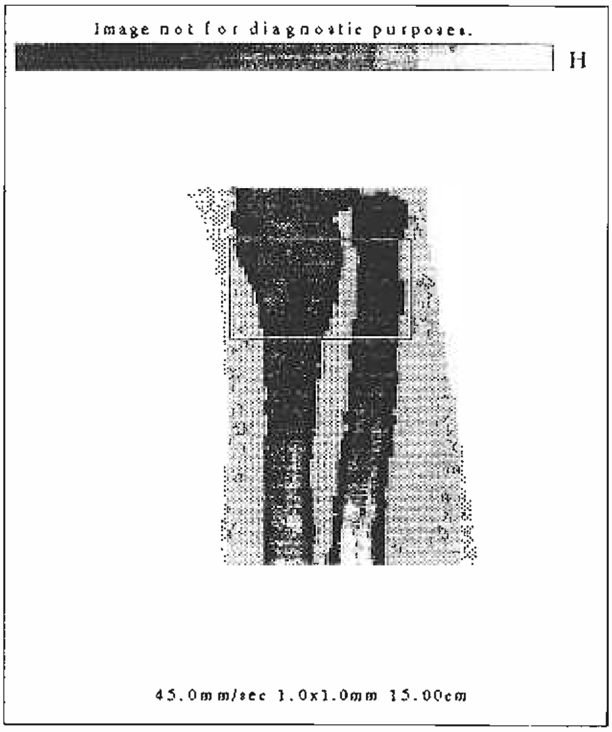
Table I - Clinical Data of the 34 Women with past Colles' fractures and 34 Healthy age- and sex-matched Controls (results expressed in Mean+S.D.)

	Patients with Colles' Fracture	Normal Controls
Number	34	34
Age, year	60.5+6.3	60.3+6.0
Height, cm	154.1+5.3	152.9+6.2
Weight, kg	52.8+8.0	51.9+9.2
Age of Menopause (year)	49.1+2.9	51.2+1.5
Menoage, year	11.2+5.0	9.2+4.5
Dominant Arms	Left: 5 Right: 29	Left: 4 Right: 30
Fractured Side	Left: 16 (incl. 5 dominant) Right: 16 Bilateral: 2	-
Time after Fracture (month)	9.4+2.6	-
Time after Removal of cast (month)	6.5+3.1	-

Fig 1 - Bone Mineral Density of 2.5 cm Ultradistal Region of the forearm as measured by the Norland XR-26 X-ray Bone Densitometer



was found to be 99% (coefficient of variation around 1%). Repeated in vivo measurements of total body and lumbar spine BMDs on three individuals resulted in precision of 98.5% (ranged from 97.8 to 99.1% for 5 consecutive measurements) and 99.0% (ranged from 98.5 to 99.2% for 5 consecutive measurements) respectively.

Bone mineral measurements were done for each subject (both patients and controls) on ultradistal forearms (both wrists), total body, lumbar spine (L_2 to L_4), and left femoral regions. The side of fractured arms in each patient was noted. The dominant and non-dominant arms of the subjects were also recorded. For the wrist scan, scanning was done from the end of the ulna to a point 10 cm proximal to it. The ultradistal 2.5 cm region of the forearm was chosen for BMD measurement, as shown in Fig 1. The scans were performed in accordance with the standard procedures provided by Norland (XR-26 Operation Manual). The total body scan required about 20 minutes while local scans of the spine, proximal femur and ultradistal forearm required 7, 8 and 5 minutes respectively.

Statistical Analysis

Student's t-test for paired data was used for comparison of BMDs between patients with Colles' fracture and age-matched controls, as well as between fractured and non-fractured ultradistal forearms of patients with Colles' fractures. Linear regression was used to determine the correlations among different regional BMDs.

RESULTS

The results are summarised in Table II. The regional distribution of BMDs were similar in both patients and normal controls. The BMD was the highest in the head, followed by the legs, arms, lumbar spine, pelvis and femoral regions. Bone mineral densities were generally lower in women with past Colles' fracture as compared with their age-matched controls. The difference was found to be significant in regions of pelvis, legs, lumbar spine, femoral neck and trochanter. There was however no significant decrease in BMD over the ultradistal part of the forearms in patients as compared with those of normal controls.

Table II - Comparison of Total Body and Regional BMDs (g/cm^2) in women with past Colles' Fractures and in Age- & Sex-matched Controls

	Women with Colles' Fracture (Mean±SEE)	Controls (Mean±SEE)	p Value (Student's t-test for paired data)
Total Body	0.65±0.01	0.68±0.01	NS
Head	1.23±0.03	1.38±0.05	NS
Trunk	0.39±0.01	0.39±0.01	NS
Pelvis	0.68±0.01	0.73±0.02	< 0.05
Legs	0.73±0.01	0.78±0.01	< 0.01
Right Arm	0.70±0.04	0.73±0.01	NS
Left Arm	0.67±0.02	0.71±0.01	NS
Lumbar Spine L_2 to L_4	0.71±0.02	0.78±0.03	< 0.05
Femoral Neck	0.60±0.01	0.66±0.02	< 0.05
Ward's Triangle	0.53±0.03	0.56±0.03	NS
Trochanter	0.51±0.01	0.56±0.02	< 0.005
Left Wrist	0.31±0.02	0.33±0.01	NS
Right Wrist	0.29±0.01	0.32±0.03	NS

SEE : Standard Error of Estimate [illegible]
NS : Not Significant

Among patients with past Colles' fractures of the left wrist, the ultradistal BMD was found to be significantly higher on the fractured sides when compared with individual non-fractured sides (p<0.001). Comparable BMDs were however obtained for the two sides in patients with fractured right wrist or with bilateral Colles' fracture (Table III). The BMD was 11% higher, on average, in the dominant ultradistal forearms than in the non-dominant forearms, as determined by measurements made on the 34 normal controls. When comparing the non-fractured side of patients with the dominant side of controls

Table III - Comparison of BMDs of Left versus Right Ultradistal Forearms in Women with past Colles' Fractures (Result expressed in Mean±SEE)

Fractured side	Left Ultradistal Forearm BMD (g/cm²)	Right Ultradistal Forearm BWD (g/cm²)	T-test (p value)
Left wrist	0.312±0.008	0.274±0.008	<0.001
Right wrist	0.298±0.014	0.300±0.024	NS
Bilateral	0.316±0.001	0.346±0.023	NS

SEE : Standard Error of Estimate (g/cm²)
NS : Not Significant

(25 right, 9 left), the ultradistal BMD was found to be significantly lower in the patients (patients:control = 0.287±0.008:0.330±0.013; $p<0.05$), while no significant difference was observed for comparison between non-fractured side of patients and non-dominant side of controls (patients:controls = 0.287±0.008:0.300±0.009; $p>0.1$).

The correlation coefficients with corresponding standard errors of estimate from the regression lines of BMDs among various skeletal sites are shown in Table IV. The different sets of measurements showed variable degrees of correlations, varying from a low value of r=0.38 for the Ward's triangle-left wrist pair to r=0.91 for the femoral neck-Ward's triangle pair. The pairs of measurements that have a close linear relationship (as measured by the correlation coefficient) and a small enough standard error to allow clinically useful prediction of

Table IV - Relationship between BMD Measurements at various Skeletal Sites

	Correlation Coefficient (SEE)					
	Lumbar Spine	Ward's Triangle	Trochanter	Femoral Neck	Left Wrist	Right
Total Body	0.82 (0.04)	0.61 (0.05)	0.69 (0.05)	0.64 (0.05)	0.60 (0.05)	0.61 (0.05)
Lumbar Spine	-	0.69 (0.11)	0.73 (0.09)	0.64 (0.11)	0.55 (0.11)	0.60 (0.10)
Ward's Triangle	-	-	0.70 (0.05)	0.91 (0.05)	0.38* (0.14)	0.59 (0.12)
Trochanter	-	-	-	0.79 (0.06)	0.54 (0.08)	0.60 (0.07)
Femoral Neck	-	-	-	-	0.43* (0.10)	0.56 (0.10)
Left Wrist	-	-	-	-	-	0.49 (0.06)

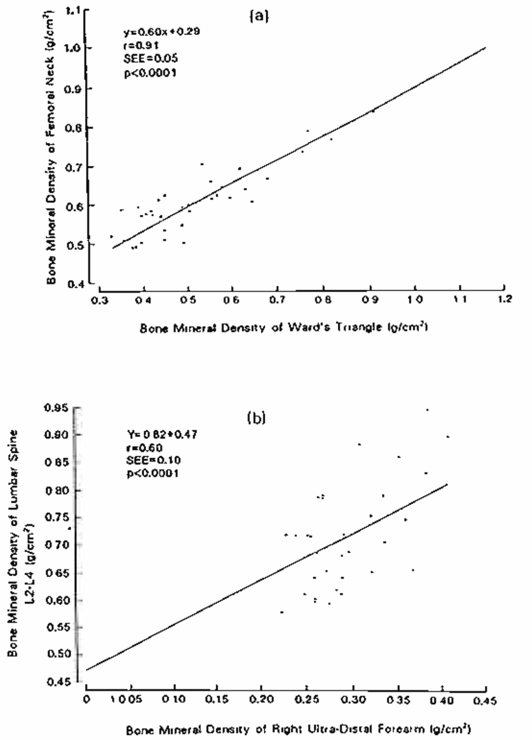
All r values: p<0.001
# p<0.005
* p<0.05
SEE: Standard Error of Estimate

BMD of one site to be made from measurement of another site were those taken over the same anatomic region. Example was the femoral regions (femoral neck, Ward's triangle and trochanter). Graphic representations of the regression data for BMDs of the femoral neck versus Ward's triangle, and those of lumbar spine versus right wrist are shown in Fig 2a and 2b.

DISCUSSION

There is considerable evidence that Colles' fracture is a true osteoporotic fracture. It is more common in postmenopausal women[19-24], and bone mineral mass is less in this age group[25]. The BMD of the radius is generally decreased by 5-14%[5,8-10,26] compared with age- and sex-matched controls, although

Fig 2 - Linear Regression Plots of BMDs among (a) Femoral Neck versus Ward's Triangle and (b) Lumbar Spine versus Right Wrist



in some studies there was little difference[11,12]. Women with Colles' fractures have also been found to have lower BMDs of lumbar spine and hip. Since decreased bone density is associated with decreased bone strength[28,29], women with Colles' fracture are also at increased risk of vertebral and femoral neck fractures.

Our results demonstrate that despite a general decrease in BMD over the ultradistal region of the wrists in patients with past Colles' fracture as compared with the normal controls, the difference is not statistically significant. When the uninjured sides (which were also the non-dominant sides) of the patients were used for comparison, the ultradistal BMDs were significantly lower than those of the dominant sides but not of the non-dominant side of the control subjects. This may suggest that increased activities of the dominant side could contribute to such significant difference in BMDs, and hence the ultradistal BMD may not be a sufficiently sensitive indicator of Colles' fracture. This contrasts the recent finding by Eastell et al who succeeded in applying a gradient-of-risk approach to predict the pattern of Colles' fracture incidence with age in normal women based on ultradistal BMD measurements[30]. Among the women with past Colles' fractures, the fractured sides showed an increase in ultradistal forearm BMDs, and this increase was statistically significant among those with left wrist fractures. This is in agreement with the finding by Finsen et al who believe that such increase was due to mineral changes induced by the healing process[31]. Such difference was however not observed at a significant level in patients with right wrist fractures. Patients with bilateral fractures showed a comparable level of BMDs on both sides.

Different regions of BMD measurements are also evaluated in this study. It has been suggested that lumbar spine measurement lacked predictive value with respect to the bone mineral content of the hip[32]. The results of this study confirm and expand upon previous findings, with the correlation coefficients between ultradistal forearm and either spine or femoral BMD measurements consistently falling below r=0.60. This is in agreement with the finding by Seldin et al in which all the r values fell below 0.50[33]. The correlation between spine and femoral sites is better, ranging from 0.64 to 0.73. The spine measurement is closely correlated to the total body BMD measurement, and seems to provide an accurate measure (SEE=0.04) of the whole body mineral status. However, as the comparisons are associated with a high degree of variability evidenced by the large standard error of estimate (SEE), it would thus be difficult to determine with confidence the mineral content of any other part of the skeleton than the one being measured. Nevertheless, site-specific measurements of BMD are probably the best way to study osteoporotic fracture syndromes and to estimate fracture risk prospectively.

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