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Original Article

Is Distal Forearm Fracture in Men due to Osteoporosis?

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Abstract. Although widely regarded as a disease of women, osteoporosis does cause considerable morbidity and mortality in men. The lifetime risk of an osteoporortic fracture for a man is 1 in 12 and 30% of all hip fractures occur in men. In women, low-trauma distal forearm fracture is widely regarded as a typical early manifestation of postmenopausal osteoporosis. Traditionally, this has not been thought to be the case for men. We present a case–control study of 147 men with distal forearm fracture compared with 198 age-matched controls. The controls were selected from a pre-existing database of dual-energy X-ray absorptiometry scans of healthy volunteers. Both groups were sent questionnaires regarding basic demographics, fracture history and risk factors for osteoporosis, and the fracture group was asked to attend for bone densitometry. There were 103 responses from the fracture group (70%), of whom 67 (47%) underwent densitometry. There were 165 (83%) responses from the control group. Secondary causes of osteoporosis could be identified in 51% of the fracture group and 37% of the control group. The fracture group had significantly lower bone mineral density at all sites measured compared with the controls (0.75 g/cm^2 vs 0.85 g/cm^2 at the femoral neck, $p < 0.0001$; 0.95 g/cm^2 vs 1.03 g/cm^2 at the total femur, $p = 0.001$; and 0.99 g/cm^2 vs 1.06 g/cm^2 at the lumbar spine, $p = 0.001$). These differences remained after adjusting for age and body mass index ($p < 0.0005$ at all sites). Overall, 41.8% of the fracture group were osteoporotic in at least one site (T-score < -2.5 SD below the mean for young men) compared with only 10.3% of controls. This study is the first to demonstrate that men with distal forearm fractures have lower bone mineral density than their peers and a higher risk of osteoporosis.

Keywords: Forearm fractures; Male; Osteoporosis

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Introduction

Although widely regarded as a disease of women, osteoporosis causes significant morbidity and mortality in men. The lifetime risk of an osteoporotic fracture of the hip, spine or distal forearm for a man is 1 in 12 and 30% of all hip fractures occur in men [1]. The standardized mortality ratio for proximal femoral fracture is 3.7 in men compared with 2.18 for women [2]. Vertebral fractures too carry considerable morbidity, with men scoring poorly on the Nottingham Health Profile [3]. The absolute number of men presenting with osteoporotic fractures is rising, because of the aging population and an increase in the age-specific incidence of fractures [4–6]. It would therefore be desirable to be able to detect male osteoporosis at an earlier stage with the aim of preventing future fracture.

In women, low-trauma distal forearm fracture is widely regarded as a typical early manifestation of postmenopausal osteoporosis [7,8]. Indeed, 50% of women who suffer a distal forearm fracture of Colles' type will have osteoporosis [9]. Traditionally, this has not been thought to be the case for men. This is partly because the incidence of these fractures is much lower in men than in women at 9 per 10 000 person-years as opposed to 36.8 per 10 000 person-years [10] and does not increase with age in the same way. It has been suggested [7] that this is because men have a higher peak bone mass at this site than women and have no decrease in distal forearm bone mineral density (BMD) with age.

However, Cuddihy et al. [8] have shown that men have a 2.7-fold and a 10.7-fold increase in hip and vertebral fractures respectively following a distal forearm fracture. This suggests that the assumption that distal forearm fractures are not important in men may be incorrect. The aim of this study was to determine whether or not men with distal forearm fractures have lower BMD than healthy age-matched controls.

Subjects and Methods

Subjects

A retrospective case–control study design was chosen and local research ethics committee approval was obtained. All subjects gave their written, informed consent. All men aged 40–80 years who had suffered a distal forearm fracture between 1996 and 1998 were identified from the Accident and Emergency Department records of attendance at Derbyshire Royal Infirmary. The case notes and radiology reports were then examined to ensure that a fracture had in fact taken place. Men under 40 years of age were excluded because they generally have a low risk of osteoporosis and 94% of fractures in this group are due to high trauma [11,12]. Subjects were also excluded if they had subsequently died, no longer lived in the area, were incapable of giving consent, had been assaulted, had not actually sustained a fracture or turned out to be women incorrectly coded as men. In this way 147 eligible men were identified of whom 103 responded to questionnaires. The subjects were divided into high- and low-trauma groups according to the questionnaire responses. If no questionnaire was available the degree of trauma was determined from the Accident and Emergency records. Low trauma was defined as a fall from standing height or less. High trauma was defined as: a fall from more than standing height (e.g., from a ladder or rooftop), sports injuries, being struck by heavy objects and road traffic accidents.

A total of 198 controls were selected from a pre-existing local database of 692 healthy men without distal forearm fractures, i.e., a ratio of two controls to each fracture subject agreeing to take part. The controls were selected purely to be matched by age to the nearest year. These men had all attended for bone densitometry in 1998. They had been recruited from the city of Derby and its environs via notices in general practitioner practices and local newspapers. All were volunteers who had consented to dual-energy X-ray absorptiometry (DXA). The fracture and control groups came from the same geographical area.

Methods

All subjects (both fracture and control groups) were sent a questionnaire. This was aimed at establishing basic demographic data, the site of fracture, degree of trauma involved, previous fractures and risk factors for osteoporosis. Subjects were asked about episodes of back pain, height loss, immobilization (for a minimum of 8 weeks), physical exercise (regular exercise being defined as more than 30 min continuous activity at least once per week), family history of osteoporosis (either a definite diagnosis or a low-trauma hip fracture in a first-degree relative), smoking, excess alcohol consumption (defined as greater than 21 units per week), medications and medical conditions. Subjects were asked specifically whether they took calcium, vitamin D, bisphosphonates, calcitriol, warfarin, corticosteroids, anticonvulsants or testosterone supplementation. Subjects were also asked if they suffered from asthma, epilepsy, kidney disease, hyperthyroidism, eating disorders, celiac disease, inflammatory arthritis including rheumatoid arthritis, liver disease, gastrectomy, inflammatory bowel disease or any other illnesses. Putative secondary causes of osteoporosis were classified as the use of warfarin, anticonvulsants, oral corticosteroids, excess alcohol consumption, long-term immobilization, gastrectomy, liver disease, inflammatory bowel disease, celiac disease, inflammatory arthritis, anorexia nervosa and hypogonadism.

The fracture group was invited to attend for DXA scanning. The scans were all performed in the second half of 1999. The BMD was determined for the femoral neck, total femur and lumbar spine (L1 to L4 anteroposterior, A–P spine) using a Hologic QDR 2000 densitometer (Hologic, Waltham, MA). Hip measurements were always taken from the left side. Results were obtained both as absolute areal density values in grams per square centimeter and as standard deviation units related either to the mean value for young adult men (*T*-score) or to the age- and sex-matched mean value (*Z*-score). The *Z*-scores were calculated using the manufacturer's standard normal reference database. These results were then compared with those for the control subjects.

Statistical analysis was performed using a standard statistical software package (Graphpad Prism) and SPSS for Windows (SPSS, Chicago, IL). Descriptive statistics were obtained and the data were then tested for normality. Data which conformed to a normal distribution were analyzed using paired and unpaired *t*-tests as appropriate. The chi-square test was applied to the questionnaire data. Finally, correlation coefficients were calculated for both age and body mass index (BMI) with BMD, regression analysis performed and data adjusted for age and BMI.

Results

Responses

Of the 147 eligible men with fractures, 103 (70%) responded to the questionnaire and 67 (46%) agreed to undergo DXA scanning. Only one of the nonresponders had died. Examination of the Accident and Emergency

Department records could establish no significant differences in terms of mean age (58.86 years in nonresponders, 60.89 years in responders), proportion of low- to high-trauma fractures (55.3% low-trauma in non-responders, 61.2% in responders) or the proportion of left-sided fractures (56.8% in nonresponders, 68.8% in responders). Similarly there were no significant differences between the 36 men with fractures who did not agree to DXA scans and those who did. There were no significant differences between the two in terms of mean age (61.6 and 60.6 years respectively; $p = 0.64$), BMI (22.5 vs 25.8 kg/m^2: $p = 0.72$), proportion with left-sided fracture (73% vs 67%; $p = 0.58$) and degree of trauma (57% low-trauma vs 64% low-trauma; $p = 0.49$). A total of 165 (83%) of the control men completed questionnaires. DXA scans were available on all 198 control men.

Questionnaire Results

The fracture group was first of all divided into high- and low-trauma groups and the responses of the two compared. There were 40 men with high trauma fractures and 63 with low-trauma fractures. The only significant difference between the two was that the high-trauma group undertook more regular exercise (77.5% vs 55.6%, $p = 0.02$ and OR = 2.76), probably because most sports-related injuries would be considered high trauma (Table 1). One interesting observation was that the majority of the fractures occurred on the left forearm (66 of 96 cases where the side was recorded: 69%).

Subsequent analysis compared the control group with the fracture group as a whole (Table 2). The fracture group were more likely to drink to excess (37.9% vs

Table 1. Questionnaire results for the high- and low-trauma fracture groups

	High-trauma	Low-trauma	*p* value
n	40 (39.0%)	63 (61%)	
Age, mean ± 95% CI (years)	59.36 (56.19–62.41)	61.90 (59.2–64.6)	NS
BMI ± 95% CI (kg/m^2)	25.23 (24–26.45)	25.97 (25.02–26.91)	NS
Back pain	16 (40.0%)	30 (47.6%)	NS
Severe back pain	11 (27.5%)	18 (28.6%)	NS
Height loss	5 (12.5%)	7 (11.1%)	NS
Spinal curvature	4 (10.0%)	7 (11.1%)	NS
Confined to bed (>8 weeks)	3 (7.5%)	1 (1.6%)	NS
Previous fractures	72 (55.0%)	26 (41.3%)	NS
Regular exercise	31 (77.5%)	35 (55.6%)	$p = 0.02$, OR = 2.76 (1.12–6.67)
Family history of osteoporosis	2 (5.0%)	2 (3.2%)	NS
Smoker	24 (60.0%)	28 (44.4%)	NS
Excess alcohol consumption	11 (27.5%)	28 (44.4%)	NS
Steroids	6 (15.0%)	5 (7.9%)	NS
Medical conditions	12 (30.0%)	26 (41.3%)	NS
Medications affecting BMD[a]	0	1 (1.6%)	NS
Secondary causes of osteopororsis	18 (45.0%)	35 (55.6%)	NS

Age and BMI were tested using unpaired *t*-tests and the remainder by chi-square tests.
[a] Warfarin and anticonvulsants, but excluding steroids.

Table 2. Questionnaire results: comparison of control and fracture groups

	Control group	Fracture group	*p* value
n	198	147	
Response	165 (83%)	103 (70%)	
Age, mean ± 95% CI (years)	61.48 (59.87–63.09)	60.89 (58.88–61.91)	NS
BMI ± 95% CI (kg/m^2)	26.42 (25.92–26.93)	25.69 (24.96–26.42)	NS
Back pain	66 (40.0%)	46 (45.0%)	NS
Severe back pain	63 (38.0%)	29 (28.0%)	NS
Height loss	52 (32.0%)	12 (12.0%)	$p = 0.0002$, OR = 0.32 (0.14–0.57)
Spinal curvature	11 (0.1%)	13 (12.6%)	NS
Confined to bed (>8 weeks)	24 (15.0%)	16 (15.5%)	NS
Previous fractures	74 (45.0%)	48 (47.0%)	NS
Regular exercise	133 (81.0%)	66 (64.0%)	$p = 0.003$, OR = 0.43 (0.25–0.57)
Family history of osteoporosis	22 (13.3%)	4 (3.8%)	$p = 0.01$, OR = 0.26 (0.09–0.79)
Smoker	93 (56.4%)	52 (50.5%)	NS
Excess alcohol consumption	34 (20.6%)	39 (37.9%)	$p = 0.002$, OR = 2.33 (1.35–4.00)
Steroids	14 (8.0%)	1 (1.0%)	NS
Medical conditions	94 (57.0%)	38 (37.0%)	$p = 0.001$, OR = 0.44 (0.27–0.73)
[a]Medications affecting BMD	14 (8.0%)	1 (1.0%)	$p = 0.009$, OR = 0.12 (0.01–0.82)
Secondary causes of osteopororsis	61 (37.0%)	53 (51.0%)	$p = 0.02$, OR = 1.82 (1.10–2.94)

Age and BMI were tested using paired *t*-tests and the remainder by chi-square tests.
[a]Warfarin and anticonvulsants, but excluding steroids.

20.6%, p = 0.002 and OR = 2.33) and less likely to undertake regular exercise (64% vs 81%, p = 0.003 and OR = 0.43). Furthermore, 51% of the fracture group had secondary causes for osteoporosis compared with 37% of the controls (p = 0.02 and 1.81). Conversely and unexpectedly, the control group had significantly higher proportions of men with self-reported loss of height (32% vs 12%, p = 0.0002 and OR = 0.32), family history of osteoporosis (13.3% vs 3.8%, p = 0.01 and OR = 0.26), taking medications which could lower bone density (excluding steroids; 8% vs 1%, p = 0.009 and OR = 0.12) and more ill-health than the fracture group (57% vs 37%, p = 0.001 and OR = 0.44).

DXA Scan Results

The age, BMI and BMD of the subjects were tested for normality and found to be so distributed. Both age and BMI were found to correlate well with BMD in both the control and fracture groups (Figs 1,2). Age showed a negative correlation with BMD at the total femur (–0.32 control, –0.24 fracture group) and femoral neck (–0.34 control, –0.25 fracture group) but not at the lumbar spine. BMI was positively correlated with BMD at the

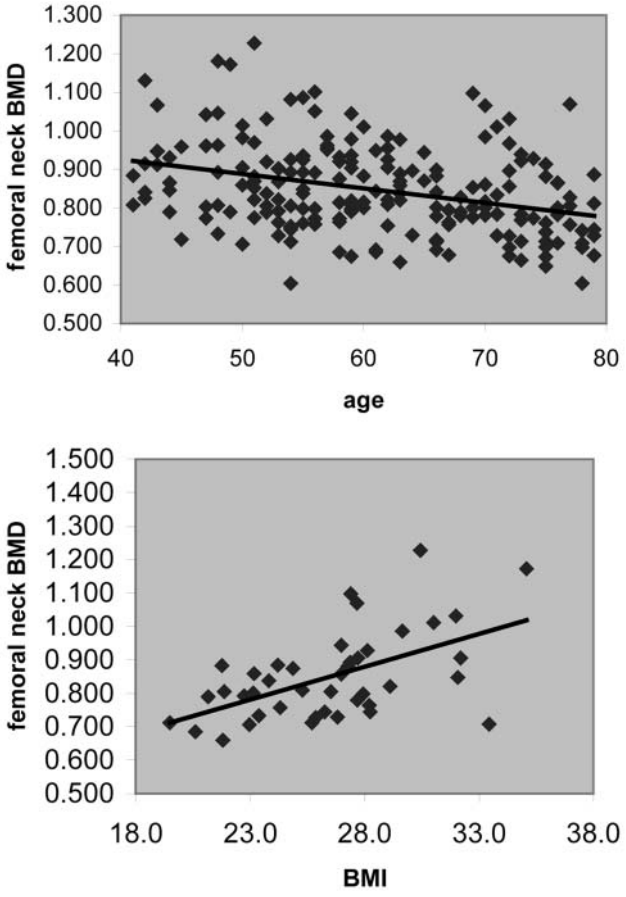

Fig. 1a,b. Correlation between age, BMI and femoral neck BMD for the control group, r ± 95% CI. **a** r = –0.34 (–0.46 to –0.21), p = 0.001. **b** r = 0.37 (0.24 to 0.49), $p < 0.0001$.

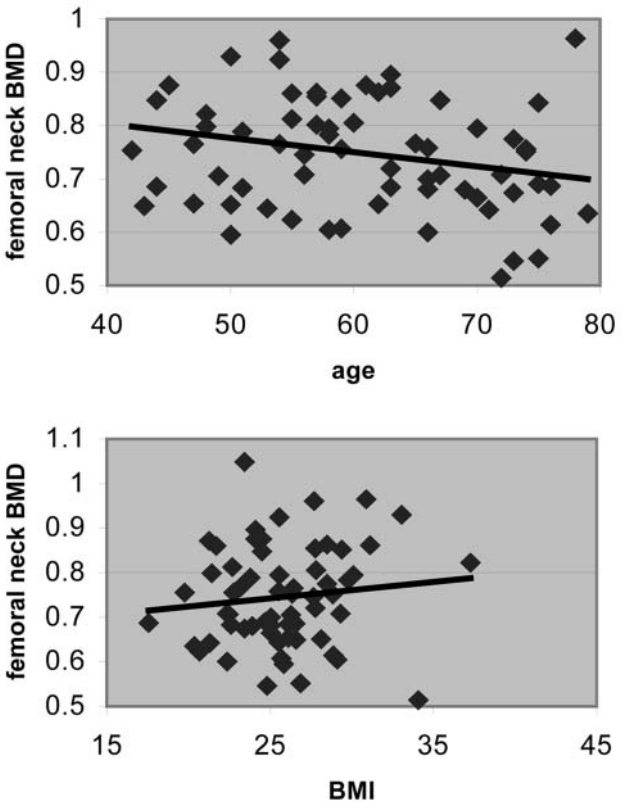

Fig. 2a,b. Correlation between age, BMI and femoral neck BMD for the fracture group, r ± 95% CI. **a** r = –0.34 (–0.46 to –0.002), p = 0.05. **b** r = 0.37 (0.13 to 0.56), p = 0.0001.

total femur (0.36 controls, 0.42 fracture group), femoral neck (0.37 controls, 0.37 fracture group) and lumbar spine (0.29 fracture group only). The two groups were matched for age and no significant difference between the control and fracture group as a whole could be found in terms of age and BMI (Tables 3,4), so matching had been successful.

The results of the DXA scans are shown in Tables 3 and 4. No significant difference was found between the low- and high-trauma fracture groups at any of the sites measured (unpaired t-tests). The BMD results for the fracture group as a whole were then compared with the control group. At all the sites measured the fracture group had a significantly lower BMD compared with the controls (0.75 g/cm^2 vs 0.85 g/cm^2 femoral neck, $p < 0.0001$; 0.95 vs 1.03 total femur, p = 0.001; and 0.99 vs 1.06 lumbar spine, p = 0.001). There was a 7.4% decrease in the lumbar spine, 7.3% at the total femur and 11.8% at the femoral neck compared with controls. As both age and BMI were found to have strong correlations with BMD, regression analysis was performed. The results for the controls (femoral neck R^2 = 0.235, SE 0.103; total femur R^2 = 0.213, SE 0.114; AP spine R^2 = 0.016, SE 0.152) and fracture group (femoral neck R^2 = 0.172, SE 0.98; total femur R^2 = 0.192, SE 0.107; AP spine R^2 = 0.109, SE 0.1398) were used to adjust the BMD for age and BMI. The analysis was then repeated

Table 3. DXA scan results for the low- and high-trauma groups

	Low-trauma	High-trauma	Difference in means (± 95% CI)	*p* value[a]
n	43	24		
Mean age, years (range)	61.9 (42–79)	59.36 (43–78)	–2.55 (–1.64 to 6.73)	0.23 (NS)
Mean BMI, kg/m^2 (range)	25.97 (17.58–34.98)	25.23 (19.7–37.28)	–0.74 (–0.81 to 2.29)	0.34 (NS)
Mean BMD (g/cm^2)				
Femoral neck	0.744	0.755	0.010 (–0.067 to 0.046)	0.72 (NS)
Total femur	0.948	0.957	0.009 (–0.074 to 0.056)	0.78 (NS)
AP spine	0.999	0.960	–0.038 (–0.036 to 0.113)	0.31 (NS)

[a]Unpaired *t*-test.

Table 4. DXA scan results for the fracture group as a whole and the controls

	Control subjects	Fracture subjects	Difference in means (± 95% CI)	*p* value[a]
n	198	67		
Mean age, years (range)	60.60 (41–79)	60.97 (42–79)	0.37 (–2.49 to 3.23)	0.8 (NS)
Mean BMI, kg/m^2 (range)	26.56 (19.5–37.08)	25.36 17.58–37.28)	0.19 (–0.71 to 1.09)	0.67 (NS)
Mean BMD, g/cm^2				
Femoral neck	0.848	0.748	0.097 (0.057 to 0.1373)	<0.0001
Total femur	1.026	0.951	0.079 (0.033 to 0.1246)	0.001
AP spine	1.065	0.985	0.087 (0.035 to 0.1387)	0.001

[a]Paired *t*-test.

(Table 5) and once again the fracture group was found to have significantly lower BMD at all the sites measured ($p < 0.0005$).

Men were classified as osteoporotic if they had a *T*-score <-2.5 SD below the mean for young men (manufacturer's data). Although this definition of osteoporosis has not been established in men it is widely used in practice. The numbers of men who were osteoporotic at each site were calculated and comparison made between the fracture and control groups using chi-square analysis (Table 6). At each site there was a significantly higher proportion of osteoporotic men in the fracture group. Overall 41.8% of the fracture group were osteoporotic in at least one site compared with 10.3% of controls. The majority of this was accounted for by the femoral neck (37.3% in the fracture group and 8.9% in the controls), with substantially lower proportions at the total femur and lumbar spine. The *Z*-scores

Table 5. DXA BMD values (g/cm^2) for the fracture group compared with the controls adjusted for age and BMI

	Control	Fracture group	Difference of the means (± 95% CI)	*p* value[a]
Number	198	67		
Femoral neck	0.8498	0.747	0.103 (0.82 to 1.24)	<0.0005
Total femur	1.0268	0.9469	0.0799 (0.056 to 0.1035)	<0.0005
AP spine	1.0628	0.9812	0.082 (0.067 to 0.0966)	<0.0005

[a]Paired *t*-test.

Table 6. *Z*- and *T*-scores for control and fracture groups

	Control subjects	Fracture subjects	Difference in means (± 95% CI)	*p* value[a]
Z-score, mean (range)				
Femoral neck	0.424 (–2.09 to 3.48)	–0.508 (–2.17 to 2.14)	0.873 (0.542 to 1.204)	<0.0001
Total femur	0.575 (–2.14 to 3.46)	0.004 (–2.00 to 2.25)	0.553 (0.216 to 0.890)	0.0017
AP spine	0.285 (–2.64 to 4.63)	–0.256 (–2.47 to 3.21)	0.457 (–0.05 to 0.965)	0.076
% osteoporotic	(*T*-score <-2.5)			
Femoral neck	8.9 %	37.3%		<0.0005
Total femur	1%	6%		0.035
AP spine	3%	14.9%		0.001
At any site	10.3%	41.8%		<0.0005

[a]Paired *t*-test.

were also lower in the fracture group than the control group, significantly so at the femoral neck and total femur (Table 6).

Discussion

This study has shown for the first time that men with distal forearm fractures have significantly lower BMD than age-matched controls. This held true even when the data were corrected for age and BMI. They also have an increased risk of osteoporosis. The percentage decrease in BMD was greatest at the femoral neck at 11.8%, with the values for the total femur and lumbar spine being 7.3% and 7.4% respectively. The reduction in BMD at the lumbar spine is of similar magnitude to that seen in women with Colles' fractures [7]. In men with vertebral fractures the greatest reduction in BMD was seen at the lumbar spine [3]. Similarly, the greatest reduction in BMD in men with hip fractures was seen at the femoral neck [13]. It is possible that this is the result of differential rates of loss resulting in a predisposition to particular fracture types. Studies incorporating distal forearm BMD would be needed to further explore this issue and to determine whether men with such fractures have the greatest percentage reduction in BMD in the forearm.

We found 41.8% of the men with distal forearm fractures to be osteoporotic in at least one site. This is comparable to that seen in women with distal forearm fractures. Earnshaw et al. [9] found a 42% incidence at the femoral neck and 50% overall in women with such fractures using the Hologic reference data, which had been validated against the local East Midlands UK population. Francis et al. [3] found 56% of men with vertebral fractures to be osteoporotic at the lumbar spine (T-score < -2.5). Pande et al. [13] found 83% of men with hip fractures to be osteoporotic at the femoral neck and 36% at the lumbar spine, but the men in this study were older (mean 78.4 years compared with 60.97 years for our study).

We were unable to demonstrate any significant difference between the BMD of the high- and low-trauma fracture groups. This was unexpected, but may have been due to errors in correctly identifying the degree of trauma involved, as this was determined purely from the questionnaire responses. However, the numbers in these subsets were quite small. Only 24 in the high-trauma group had DXA scans and so only a few would need to be incorrectly classified to affect the result. Furthermore, both fracture groups alone and in combination had significantly lower BMD than the control group.

We found that 51% of the fracture group had identifiable secondary causes for osteoporosis compared with 37% of the control group. This is similar to the 55% found previously in men with symptomatic vertebral fractures in the United Kingdom [14,15] and in other centers around the world [16,17]. This adds further to the evidence that secondary causes of osteoporosis are common in men with osteoporotic fractures.

The majority (69%) of fractures occurred on the left-hand side. This left predominance has previously been reported in observational studies by Lindau et al. [12] and O'Neill et al. [10]. O'Neill et al. argued that this was due to a lower bone mass in the nondominant hand compared with the dominant, which would be the right hand for the majority. It may also be that right-handed people were more likely to be using that hand at the time of injury and so used their left to break their fall.

The study has a number of potential weaknesses. It is both relatively small and retrospective. Although, there was a good response rate to the questionnaire (70% of the fracture group and 83% of the control group), only 46% of the eligible fracture subjects agreed to undergo DXA scanning. However, there were no significant differences in age distribution, degree of trauma or fracture site between responders and nonresponders. Similarly there were no significant differences in mean age, mean BMI, degree of trauma and fracture site between those agreeing to a DXA scan and those who did not. One reason for the low response may have been lack of awareness. A previous survey of these men with distal forearm fractures by us found only 5% thought they might be at risk of osteoporosis, 1% had consulted their general practitioner about the fracture and 1% had undergone a DXA scan [18]. Many of the men were younger and still working and so may have been unable to take part.

The fracture subjects were recruited some time after their fractures. Although the fracture subjects had been age-matched with controls, it is possible that the fracture could have resulted in a change of lifestyle which may have had an effect on the BMD. However, this seems unlikely as so few thought themselves at risk of osteoporosis and even fewer consulted their doctors about the fracture [18]. They therefore had no reason to alter their lifestyle. The possible change in BMD is nonetheless a concern common to all cross-sectional studies. It is probably not a major factor in this instance, as most of the men had no identifiable reason for rapid bone loss. This question could be addressed by a prospective study with bone mass measurements closer to the time of fracture.

The control group had a significantly greater likelihood of having a family history of osteoporosis than the fracture group (13.3% vs 3.8% and OR of 3.81). The control group also had a significantly greater proportion of men with loss of height, who were taking medications that could have affected BMD and greater ill-health. Such men may have been more likely to volunteer and could have biased the result. However, all these factors would have a tendency to lower BMD and reduce any difference between the control and fracture group BMD. Furthermore, the mean Z-scores of the controls were greater than zero at all sites and significantly higher than in the fracture group, suggesting that bias has not occurred.

Conclusion

Despite the limitations of the study, which have already been mentioned, we feel that the results are both valid and important for the study of male osteoporosis. This study has shown, for the first time, that men with distal forearm fractures have a significantly lower BMD at all sites measured than the normal population and hence have an increased risk of osteoporosis. Until now it has been assumed that distal forearm fracture in men is not a significant health problem, because the fracture may be related to high trauma and there is neither a fall in distal forearm BMD nor an increased risk of forearm fracture with age [7]. The finding of increased risk of hip and vertebral fracture following distal forearm fracture by Cuddihy et al. [8], along with our own data, suggests that this assumption may have been incorrect. We would suggest that men suffering this type of fracture should undergo DXA scanning and be screened for risk factors related to osteoporosis and falls. Larger, prospective studies with long-term follow-up are urgently required to substantiate these important findings.

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