Calcaneal bone mineral density in older patients who have fallen

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Summary

Background: Annually, 35–40% of those aged >65 years fall; up to 5% of such falls result in fracture. Fracture is determined both by propensity to fall and by bone fragility.

Aim: To determine osteoporosis prevalence and predictors in patients who have fallen.

Design: Observational cross-sectional study.

Methods: We measured calcaneal BMD in 408 consecutive patients aged >50 years attending after falling. Fall number, fracture history, weight, height, and risk factors for falls and osteoporosis were recorded. T scores (SD above or below the mean for young adults) were derived in both sexes, and Z scores (SD above or below age-related normal score) in females.

Results: In females (n=300, 74%), mean (SD) T score was −1.1(1.6), and mean Z score was 0(1.4); 127 (42%) had osteoporosis (T score < −1.6). ROC curves confirmed significant relationships between osteoporosis and age, weight and height (all p<0.0001). Incorporating fracture history, our model (fracture aged >50 years, age >83 years, weight <57 kg, height <153 cm as dichotomous variables) predicted osteoporosis with 91% sensitivity, 34% specificity. Of 108 male fallers, 36 (33%) had osteoporosis. Age, height and weight all predicted osteoporosis (p<0.02). The resulting model (fracture aged >50 years, age ≥80 years, weight ≤68 kg, height ≤167 cm as dichotomous variables) predicted osteoporosis with 92% sensitivity, 30% specificity.

Discussion: Osteoporosis prevalence is not increased in female fallers compared to age-related norms; empirical use of osteoporosis treatment solely on the basis of falls thus appears inappropriate. In both sexes, the factors predicting osteoporosis were age, height and weight. Where BMD is not practical, possible or economical, our model may be a sensitive means of predicting fallers with osteoporosis.

Introduction

Falls are among the most common and serious problems facing older people, and are associated with considerable morbidity, mortality, reduced functioning and premature nursing home
Each year, approximately 35–40% of people aged >65 years fall, with up to 5% of such falls resulting in fracture. Hip fracture is one of the most costly and debilitating outcomes resulting from a fall, but occurs in only 1% of falls. However, 90% of hip fractures occur because of a fall. Studies have shown that the great majority of upper extremity fractures also occur as a result of a fall.

Osteoporosis is defined as a bone mineral density measurement (BMD) of more than 2.5 SD below the mean value for young adults (T score < –2.5). There is a strong inverse relationship between BMD and fracture risk, with a 2–3-fold increase in fracture incidence for each standard deviation reduction in BMD. Although one small study has shown increased risk of hip fracture in fallers with low BMD, it is unclear whether osteoporosis is present in most or all fallers who sustain a fracture. It is also uncertain whether other risk factors can identify fallers at increased risk of osteoporosis, which would allow targeted interventions.

Fracture is determined both by the propensity to fall and by the underlying bone fragility. The UK National Service Framework (NSF) for Older Persons recommends that osteoporosis prevention and treatment should be considered in all fallers who are at risk of fracture, although the most effective means of delivering an effective falls and osteoporosis risk factor assessment into a Falls Service is unclear, particularly where easy access to BMD measurements is not available.

We have previously published data on the use of peripheral bone density measurements in a Falls Service, and confirmed their reliability in females, when compared to the gold standard of Dual energy X-ray absorptiometry (DXA) at the hip and spine. Here we present our experiences with the use of peripheral DXA (pDXA) BMD measurements in female and male fallers attending our Falls clinic. This study set out to determine the prevalence of osteoporosis in 408 fallers, and to determine whether groups at increased risk of osteoporosis could be identified. We have also sought to further validate the use of portable devices for BMD measurement in fallers.

Methods
Calcaneal BMD was measured in consecutive patients aged >50 years attending the Regional Falls and Syncope Service for investigation of falls. In our service, 76% of patients are referred from local General Practitioners or secondary care colleagues, with the remainder being tertiary referrals.

Patients provided details of the total number of falls over the last year, and fracture history over the age of 50. In cognitively impaired patients, the history of falls and fall frequency was corroborated by a relative or carer. All patients had a comprehensive multidisciplinary falls risk assessment. A recurrent faller was defined as someone who had had two or more falls in the preceding year.

Gait and balance was examined in the out-patient setting using a ‘get up and go’ test, and classified as normal or abnormal, by an assessor who was blinded to the results of the bone density measurements. Weight and height were recorded, and where applicable, details of risk factors for osteoporosis were also recorded, including age at menopause, medications that accelerate bone loss, and excess alcohol consumption, together with their use of treatments for osteoporosis.

All patients underwent pDXA measurements at the calcaneum, using a peripheral instantaneous X-ray imaging DXA system (PIXI, Lunar). Daily quality assurance checks were performed before use, as recommended by the manufacturers.

Individual BMD (g/cm²) measurements were compared with mean values for young adults and age-related normal subjects to give T scores (number of SD units above or below the mean for normal young adults) in both sexes, and Z scores (number of SD units above or below the mean for age-related normal mean) in females. Osteoporosis was defined as a calcaneal BMD T score of < –1.6, which the manufacturers suggest is equivalent to the WHO criteria for osteoporosis of a T score of < –2.5 at the spine or hip. This suggestion is supported by previous studies comparing the results of calcaneal and hip BMD.

Where variables were parametric, data are presented as mean and SD, and comparisons were made between groups using the student’s t test. Where variables were non-parametric, data are presented as median and range, and comparisons made using Mann-Whitney tests. Correlation analyses and logistic regressions were obtained using ‘Prism-Graphpad’ [http://www.graphpad.com/prism/Prism.htm]. ROC curves were generated using ‘Analyse-it’ [http://www.analyse-it.com/]. A value of p < 0.05 was considered statistically significant.

Results
We measured calcaneal BMD in 408 consecutive patients aged >50 years attending our unit for
investigation of falls; 108 (26%) were male and 300 (74%) female.

Measurement of heel BMD using pDXA in female fallers

Demographic details and BMD measurements of the 300 females are shown in Table 1. The mean (SD) T score for females was −1.1(1.6), with mean Z score 0(1.4), suggesting that bone density measured at the calcaneum is no different in fallers than would be expected in a female population of the same age.

Of the 300 female fallers, 129 (43%) had a previous history of fracture sustained over the age of 50. Mean (SD) T score was significantly lower in those with fracture history than in those without: −1.3(1.5) vs. −0.9(1.6) (p = 0.02) (Table 1). There were no significant differences between females with and without fracture history in terms of age, number of falls in the preceding year, height or weight.

Of the total group of female fallers, 127/300 (42%) had osteoporosis (T score < −1.6). Compared to those without osteoporosis, females with osteoporosis were significantly older (p < 0.0001), had sustained significantly more fractures (p = 0.04), and were significantly shorter (p < 0.002) and lighter (p < 0.0001).

ROC curves were used to determine the sensitivity and specificity of an individual parameter for detecting osteoporosis, using age, weight, height, number of falls, early menopause, and four or more medications, as independent predictors. In females, a significant relationship was seen for age, weight and height (Figure 1) (all p < 0.0001), but not for the other parameters (all p > 0.2). When developing a model to predict osteoporosis in older females who have fallen, we considered the 80% sensitivity level for those significant parameters (age, height, weight), and developed a predictive model that included history of fracture. The resulting model (fracture history over the age of 50, age > 83 years, weight < 57 kg and height < 153 cm, all as dichotomous variables) predicted osteoporosis (T score < −1.6) with 91% sensitivity, at the expense of a low 34% specificity (p < 0.0001). (Figure 2). Positive predictive value (PPV) (i.e. the probability that a person has the osteoporosis given that the model predicts they do have) was only 41%, but reassuringly, the negative predictive value (NPV) (i.e. the probability of the model correctly identifying those who do not have the disease) was 90%.

Measurement of heel BMD using pDXA in male fallers

We measured calcaneal BMD in 108 males, mean (SD) age 75 (9) years. They had sustained a mean

Table 1  Bone mineral density measurements in males and female fallers

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>n</td>
<td>108</td>
</tr>
<tr>
<td>Mean (SD) age (years)</td>
<td>75 (9)</td>
</tr>
<tr>
<td>Median falls (range)</td>
<td>3 (1–20)</td>
</tr>
<tr>
<td>Median fractures (range)</td>
<td>0 (0–3)</td>
</tr>
<tr>
<td>BMD</td>
<td>0.6 (0.1)</td>
</tr>
<tr>
<td>T score</td>
<td>−0.8 (1.4)</td>
</tr>
<tr>
<td>Z score</td>
<td>–</td>
</tr>
<tr>
<td>Height</td>
<td>171 (7)</td>
</tr>
<tr>
<td>Weight</td>
<td>75 (14)</td>
</tr>
<tr>
<td>Osteoporosis present (%)</td>
<td>36 (33%)</td>
</tr>
</tbody>
</table>

*Significant difference between those with a fracture history (when aged >50 years) and those without.

Figure 1. ROC curve examining the ability of each of the following parameters to predict osteoporosis in females: age, height, weight (all relationships p < 0.0001).
incorporating them into a similar model to that for female fallers (fracture history aged >50 years, age >80 years, weight <68 kg, height <167 cm, all as dichotomous variables) again predicted osteoporosis with high sensitivity (92%) but low specificity (30%). PPV was 40% and NPV 89%.

**Discussion**

Falls and osteoporosis are major chronic diseases common in older people. The present study examined peripheral bone density in a cohort of fallers, and found that in females, BMD was similar to that expected in this age group. This suggests that the prevalence of osteoporosis is not increased in female fallers, and that routine empirical use of osteoporosis treatment is therefore inappropriate at present. As might be expected, those female fallers who had sustained a fragility fracture over the age of 50 had significantly lower T and Z scores compared to females who had not fractured, but, interestingly, there was no significant difference in the number with osteoporosis.

In male fallers attending a falls service, we have been unable to explore whether the BMD is lower than expected on the basis of age, as there are insufficient normative data to calculate Z scores. There is a paucity of data on the prevalence of osteoporosis in men, partly reflecting the fact that the WHO definition was developed for women only. Increasingly, people are using the T-score threshold of $-2.5$ in men, but there is discussion as to whether this should be calculated using the male or female normative data. Data from the US show a prevalence of osteoporosis (T $<-2.5$ calculated using male normative data) of 19% in men aged >50 years. But in the UK, studies suggest a lower prevalence of 2.7% in 65-year-old men. The frequency of osteoporosis in our male fallers was 33%, suggesting that osteoporosis (particularly causes of secondary osteoporosis) should be considered in the clinical evaluation of in male fallers with fractures.

Strong relationships between height and weight in both males and females have allowed us to consider predictive models for detecting the presence of osteoporosis in those attending with falls. In our previous smaller series exclusively in females, where we validated the use of peripheral bone density measurement in a falls clinic, we suggested that fallers with two or more risk factors for falls were more likely to have osteoporosis, and that targeting treatment at those with more risk factors might be clinically appropriate. However, we also suggested that as osteoporosis was not a universal finding

![Figure 2. ROC curve examining the ability of a predictive model to detect the presence of osteoporosis in females with one of the following: history of fracture aged ≥50 years, age ≥83 years, weight ≤57 kg, height ≤153 cm (91% sensitivity, 34% specificity, p<0.0001).](image)

![Figure 3. ROC curve examining the ability of each of the following parameters to predict osteoporosis in males: age, height, weight (all relationships p<0.02).](image)
in those with two or more risk factors, ideally all subjects attending a Falls Service should have BMD measured. In the current study, involving greater numbers of patients, we have been able to determine factors that predict osteoporosis in older fallers. In both males and females, as might be expected, these are age, height and weight. Treatment for osteoporosis is currently recommended in the UK in all women aged >65 years with a low-trauma fracture without bone density measurement.  

We therefore incorporated previous fracture history into our models. Despite the high sensitivity of our model (i.e. ability to detect osteoporosis if the model defines it as present), the specificity was poor (i.e. the model would potentially end up treating a high number of patients who did not have osteoporosis). This was largely because we felt mandated to incorporate previous history of fracture into our model, in line with current guidelines for secondary prevention of fractures in older people. However many patients with a fracture history did not have osteoporosis, resulting in poor specificity.

We would reiterate the need for BMD measurement in those at risk of fractures, but in circumstances where this is not practical, possible or economical, our model may be a sensitive means of predicting those fallers with osteoporosis. In our unit, we intend to continue validating this model, and we acknowledge that further prospective studies in other centres are necessary. Further work, by including collection of extensive data with regard to other risk factors for osteoporosis, will potentially yield models that perform even better than the one proposed in this study.

Our results suggest that peripheral BMD measurement is a reliable method for determining osteoporosis prevalence, even in those with no history of fracture. Further studies are required, to determine whether treatment of osteoporosis in fallers (a group at increased risk of fracture) does in fact reduce fracture rates. In addition, it is also critical that work is directed towards determining whether giving bone-strengthening medication to fallers with increased risk of fracture but no (or borderline) osteoporosis may also prevent fractures.

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References


