EXTENDED REPORT

A clinical tool to determine the necessity of spine radiography in postmenopausal women with osteoporosis presenting with back pain

C Roux, G Priol, J Fechtenbaum, B Cortet, S Liu-Léage, M Audran

See linked editorial, p 2

Ann Rheum Dis 2007;66:81–85. doi: 10.1136/ard.2006.051474

See end of article for authors' affiliations

Correspondence to:
Professor C Roux, Assistance
Publique-Hôpitaux de Paris,
Université Paris-Descartes,
Hôpital Cochin, service de
Rhumatologie, 27, rue du
Faubourg Saint Jacques,
Paris 75014, France;
christian.roux@cch.
ap-hop-paris.fr

Accepted 9 June 2006
Published Online First
22 June 2006

Background: Vertebral fractures are underdiagnosed, although the resulting mortality and morbidity in postmenopausal women with osteoporosis is now recognised. In a population of postmenopausal women with osteoporosis and back pain, symptoms may be related to vertebral fractures or degenerative changes of the spine.

Aim: To evaluate a population of postmenopausal women presenting with back pain and factors associated with vertebral fractures which were assessable in a clinical setting in order to determine the necessity for spine radiography.

Methods: Patient questioning and physical examination were carried out and spinal radiographic data collected from 410 postmenopausal women with osteoporosis, with an average age of 74 years, who consulted a rheumatologist for back pain. Of these, 215 (52.4%) patients were diagnosed with at least one vertebral fracture. Logistic regression was used to identify the most relevant clinical features associated with existing vertebral fractures, and to derive a quantitative index of risk.

Results: The model included six parameters: age, back pain intensity, height loss, history of low trauma non-vertebral fractures, thoracic localisation of back pain and sudden occurrence of back pain. The scoring system, or the quantitative index, had a maximal score of 16. For a score ≥ 7 , the probability of existing vertebral fracture was $\geq 43\%$. The correlation between this quantitative index and the logistic model probability was 0.98, suggesting an excellent and highly significant approximation of the original prediction equation.

Conclusions: From six clinical items, an index was built to identify women with osteoporosis and back pain who should have spine radiography. This simple tool may help clinicians to optimise vertebral fracture diagnosis and to make a proper therapeutic decision.

Vertebral fractures are the most common osteoporotic fractures, occurring in approximately 20% of postmenopausal women.¹ They are a strong risk factor for subsequent peripheral fractures, including hip fracture,² and incident vertebral fractures.³ The risk of vertebral fractures in women with one prevalent fracture is 2–4 times that in women without prevalent fractures, whereas for women with three or four prevalent fractures, the risk is almost 6 times higher.³ The greater the number and severity of fractures, the worse the quality of life.^{4–5} Furthermore, patients with multiple fractures or clinical vertebral fractures are at increased risk of death.^{6–7} Most evidence for the efficacy of anti-osteoporotic drugs has been obtained in patients with vertebral fractures.

Although their consequences are now recognised, vertebral fractures are underdiagnosed. Two thirds of vertebral fractures are not brought to clinical attention,⁸ either because they are asymptomatic or because symptoms are not attributed to osteoporosis. Height loss, chronic back pain and back-related functional disability can be the consequences of both vertebral fractures⁹ and osteoarthritis of the spine. Height loss is associated with vertebral fractures, and there is a nearly fivefold increased risk of existing vertebral fractures in women having lost more than 3 cm since age 25 years.¹⁰ However, this symptom is not specific to osteoporosis and may be related to intervertebral disc degenerative changes or changes in spine curvature. Two thirds of adults have low back pain at some time, and there has been controversy about the need for spine x rays for back pain.¹¹ In a population of postmenopausal women, back pain can be the result of several spine diseases, including intervertebral disc degeneration and facet joint arthritis, or

recent vertebral fractures.^{12–13} Thus, no single clinical sign has the ability to identify women most likely to have existing radiographic vertebral fractures.

Advancing age and low bone mineral density have been associated with existing vertebral fractures, but because of both radiation concerns and cost, spine radiography cannot be used to screen all women with osteoporosis. It is possible to optimise the selective use of spine radiography using an index based on age, height loss and history of fracture.^{14–15} This epidemiological approach is far from the day-to-day care of women with osteoporosis. Doctors usually make the decision for radiography on a case-by-case basis; in a woman with back pain, the balance is between the concern over unnecessary radiation (if pain is related to degenerative changes) and the importance of imaging the spine for making a treatment decision (if there is a vertebral fracture).

The aim of this analysis was to develop rules for using spine radiography to identify postmenopausal women with osteoporosis and back pain with a high potential for having vertebral fractures. We studied the factors associated with these fractures, which were easily assessable in a clinical setting.

PATIENTS AND METHODS

Patients

Rheumatologists, predominantly in private practice, recruited patients for a longitudinal prospective study aimed at assessing

Abbreviations: BMD, bone mineral density; EPOS, European Prospective Osteoporosis Study; VAS, visual analogue scale

Table 1 Patient characteristics

	Prevalent vertebral fracture		Total (n = 410)	p Value
	Yes (n = 215)	No (n = 195)		
Age (years), mean (SD)	75.8 (5.2)	72.7 (5.4)	74.3 (5.5)	<0.001
n	214	194	408	
Age at menopause (years), mean (SD)	49.2 (5.1)	48.6 (6.0)	48.9 (5.5)	NS
n	215	195	410	
Weight (kg), mean (SD)	60.3 (11.8)	60.9 (11.4)	60.6 (11.6)	NS
n	214	195	409	
Height measured (cm), mean (SD)	153.5 (6.2)	155.4 (6.0)	154.4 (6.2)	0.002
n	207	191	398	
Height at 25 years (cm), mean (SD)	159.7 (5.4)	159.3 (5.7)	159.5 (5.5)	NS
n	206	191	397	
Difference: height at 25 years – present height (cm), mean (SD)	6.1 (3.7)	3.8 (2.3)	5.0 (3.3)	<0.001
History of low-trauma fractures, including vertebral fracture (%)	49.8	25.3	38.1	<0.001
History of low-trauma fractures, excluding vertebral fracture (%)	29.3	24.8	27.1	NS
Spine diseases (%)	77.2	79.4	78.2	NS

the costs incurred by vertebral fracture management. The baseline data are the basis of this study. Subjects included were ambulatory postmenopausal women, aged 65–85 years, satisfying two criteria: (1) the reason for the consultation was back pain; (2) they were osteoporotic on the basis of bone mineral density measured by dual-energy x ray absorptiometry of the spine, femoral neck or total femur (using the World Health Organization definition). They were not allowed to receive bisphosphonates, selective oestrogen receptor modulator or hormone replacement therapy for at least 3 months before the time of inclusion. Back pain was defined by thoracic or lumbar pain with visual analogue scale (VAS) ≥ 40 mm. Informed written consent was obtained from the patients, and the study was approved by the local ethics committee.

Measurements

Only clinical and sociodemographic data collected during the inclusion visit were used in this analysis. Demographic data concerned age, present and given height at age 25 years, weight, type and duration of menopause. Clinical data were focused on the patient's personal history of spine and peripheral fractures, and history of spine disease including osteoarthritis, from the patient's records. Characteristics of back pain assessed during the visit were duration, location (thoracic or lumbar), occurrence (rapid or progressive), intensity (according to VAS), as well as time of worsening (day or night) and intermittence. The potential increase of back pain by flexion/extension of the spine was assessed by physical examination. Bone mineral density (BMD) data were not retained in the analysis as they were not obtained at the same interval from inclusion for all patients.

Spine radiography

Radiographs of the spine according to standardised procedures for image acquisition were ordered for each patient except for those who had recent radiographs (<1 month). Three lateral radiographs (thoracic and lumbar radiographs and an image of the thoracolumbar junction) and anteroposterior incidence radiographs of the spine were obtained and sent to a single central reading facility (CEMO, Cochin Hospital, Paris, France) for confirmation of quality and evaluation of vertebral fracture by a single rheumatologist. Vertebrae from T4 to L5 were evaluated according to Genant's semiquantitative method.¹⁶ A fracture was defined as grade ≥ 1 . Vertebrae with deformity of

non-osteoporotic origin (degenerative changes) were not given a grade >0 .

Analysis

Characteristics of patients and symptoms were evaluated in logistic regression models with vertebral fracture as the outcome measure. Firstly, each predictor variable was entered into a univariate logistic regression model to determine the global effect of the variable. As suggested by Mickey and Greenland,¹⁷ we included in a multivariate model all predictors with a 20% level of significance. Then, all selected predictors were entered into a multivariate logistic model using a forward stepwise selection approach if the likelihood ratio test was significant at the 10% level. This model aims to calculate the probability of the existence of at least one vertebral fracture on radiography. The final model was then evaluated using positive and negative predictive values, and area under the receiver operating characteristic (ROC) curve. ROC curves were drawn using the sensitivity and specificity of the model to assess the discriminating threshold for the existence of prevalent fractures.

Finally, we developed decision criteria for the ordering of radiographs that could be applied easily in clinical practice. We divided the expected population scores into 12 homogeneous classes in terms of size, ranking in ascending order (the first class had the lowest probability and the last one the highest); we measured the probability of identifying a patient with a

Figure 1 Distribution of vertebral fractures.

Table 2 Characteristics of the back pain

	Prevalent vertebral fracture		Total n=410	p Value
	Yes n=215	No n=195		
Intensity (mm), mean (SD)	64.5 (13.3)	60.2 (13.7)	62.5 (13.7)	0.001
Duration (months), mean (SD)	49.3 (88.5)	74.2 (104.3)	61.2 (97.0)	0.01
Thoracic (%)	52.1	46.2	49.3	NS
Lumbar (%)	87.0	89.7	88.3	NS
Day (%)	98.1	97.4	97.8	NS
Night (%)	37.7	24.1	31.2	0.003
Day and night (%)	36.3	22.1	29.5	0.002
Localised (%)	25.1	24.6	24.9	NS
Generalised (%)	76.7	77.4	77.1	NS
Rapid (%)	52.6	22.6	38.3	<0.001
Progressive (%)	48.8	79.0	63.2	<0.001
Increase in				
Flexion (%)	80.9	71.3	76.3	0.022
Extension (%)	80.5	72.8	76.8	NS
Intermittent (%)	62.8	73.3	67.8	0.023

fracture and another without fracture in each probability interval. Then, we developed an index following a method previously proposed by Black *et al*,¹⁸ by converting the multi-variate logistic equation into an additive score. Age, as a continuous variable, was dichotomised into 5 categories (<65, 65–69, 70–74, 75–79, ≥80 years). Other parameters were used as they were in the model. The coefficients of regression were multiplied by 3 (arbitrary constant) and rounded to the nearest digit if necessary. We then tested the correlation (Spearman's test) between the probability calculated from the logistic regression and that of the additive score.

The statistical package software SAS V.8.2 was used for statistical analysis.

RESULTS

Four hundred and twenty four patients with back pain and osteoporosis were recruited. Radiographs of 14 patients were not analysed because of missing data. The reason for missing data was either that the radiograph was not performed or that the central reader deemed the radiograph to be of insufficient quality. Thus, the final analysis was based on the data collected from 410 patients. Table 1 lists the characteristics of the population. A total of 154 patients reported a history of low trauma fracture, including vertebral fractures (31.8% of reported fractures) and wrist fracture (30.5%); 215 non-traumatic fractures were reported—that is, 1.4 fractures per patient.

At baseline radiography, a total of 540 vertebral fractures were diagnosed in 215 (52.4%) patients (mean age 75 years)—that is, 2.5 vertebral fractures per patient; 38.1%, 27% and 14% of patients had 1, 2 or 3 fractures, respectively; 20.9% had at least four vertebral fractures. Figure 1 shows the localisation of fractures. Among the 82 patients with only one vertebral fracture, 18 (22%) were located in L1, 12 (14.6%) in T12; among the 58 patients with two vertebral fractures, 11 (13.8%) were located in T11 and L1. On comparison with patients without fractures (table 1), patients with vertebral fractures were found to be 3.1 years older and 1.9 cm shorter; their mean (SD) height loss was 6.1 (3.7) cm, greater than patients without fractures (3.8 (2.3) cm; $p<0.001$). As expected, in this population, almost 80% of patients had osteoarthritis. Table 2 lists the back pain characteristics. In patients with vertebral fractures, pain was more intense, but of shorter duration; more often it occurred suddenly, and persisted during the night; pain was worsened by flexion of spine.

Beginning with all the patient characteristics and pain in a single logistic regression model, we obtained a final model including six parameters (table 3). This model was based on data from 397 patients, as, to be included, each parameter needed to be completed by the investigator.

We next determined the probability of existing vertebral fracture in this population as:

Logit (P) = $-7.1082 + (0.0734 \times \text{age}) + (0.6129 \times \text{pain intensity}) + (0.6622 \times \text{height loss 1}) + (1.1723 \times \text{height loss 2}) + 0.4793$ (in case of history of low-trauma peripheral fractures) + 0.4852

Table 3 Odds ratios (95% confidence intervals) of parameters in the logistic regression model

	OR	95% CI	p Value
Age (per 1 year)	1.076	1.031 to 1.123	<0.001
Age (per 5 years)	1.444	1.165 to 1.788	<0.001
Intensity of pain (≥65 mm on a VAS)	1.846	1.171 to 2.911	0.008
Height loss (per cm)			
0: <3	1		
1: 3–6	1.939	1.081 to 3.479	0.026
2: ≥6	3.229	1.688 to 6.176	0.001
Thoracic localisation of pain*	1.624	1.031 to 2.560	0.037
Sudden occurrence of pain*	3.370	2.093 to 5.424	<0.001
History of low-trauma peripheral fracture* (pelvis, forearm, rib, hip)	1.615	0.947 to 2.755	0.079

VAS, visual analogue scale.

*Yes, 1; No, 0.

Figure 2 Comparison of model and index receiver operating characteristic curves.

(in case of thoracic localisation of pain)+1.2148 (in case of sudden occurrence of pain).

The positive predictive value of the model is 70.9% and the negative predictive value 68.6%. Area under the ROC curve (fig 2) is 0.77.

We defined two thresholds according to the repartition of the probability scores calculated by our model. The first threshold was estimated as 27%: among women with a probability score of $\leq 27\%$, 84.4% were correctly classified as “non-fractured” by the model. The second threshold was estimated to be 74%. Among women with a probability of having a vertebral fracture $\geq 74\%$, 81.8% were correctly classified as “fractured” by the model. There were no “fractured” women among those below the threshold of 13.9%. Table 4 presents the results of the scoring system; the maximal score is 16. For a score ≤ 2 , the probability of fracture is $<20\%$. When the score is ≥ 7 , the probability of fracture is $\geq 43\%$. The correlation between probabilities predicted by the scoring system and the multivariate logistic model is 0.98 ($p < 0.001$), suggesting that the score provides an excellent approximation of the original logistic model.

DISCUSSION

Our results show that the analysis of six easily assessable parameters gives a relevant tool to justify spine radiography in postmenopausal women with osteoporosis presenting with back pain, a population in which this question has not been

raised. From the scoring system we designed, it is possible to estimate the probability for a patient to have a vertebral fracture.

Even if they are not diagnosed, vertebral fractures are associated with physical disability, spine deformity and decrease in quality of life.¹⁹ Patients with these fractures are at high risk for subsequent fractures, including spine and hip fractures.³ This population will have the greatest benefit from treatment, which can decrease the risk of incident vertebral fractures by 50% on average. Thus, it is relevant to identify women with an existing vertebral fracture who may benefit from treatment.

In the presence of back pain, there is no single indicator to relate it to the presence of vertebral fracture. Confirmation of degenerative changes of the spine using radiography is not relevant for therapeutic management of a patient. This strongly contrasts with the efficacy of therapeutic strategies implemented in the presence of vertebral fracture.

In our study, half of the postmenopausal women with osteoporosis presenting with back pain had at least one vertebral fracture. This prevalence is dramatically higher than that reported in epidemiological data. In the EPOS,¹⁵ conducted in a comparatively younger population of women (65.7 years old on average), the prevalence of vertebral fractures was 13.6%; this prevalence increased with age, reaching 19% for patients 75–79 years old, and 22% for patients >79 years old. These data indicate that among postmenopausal women with osteoporosis presenting with back pain, the prevalence of osteoporotic fractures is greater than that usually reported in epidemiological surveys. Our index applies to this population, and further studies are needed to assess its performance in a less severely affected population, such as in general practice.

In our study, the strongest predictors of the existence of vertebral fractures were the sudden occurrence of pain ($OR = 3.3$) and height loss >6 cm ($OR = 3.1$). The mean height loss in patients without vertebral fracture was 3.8 cm, which reaches the threshold recognised as a potential sign of vertebral fracture.¹⁰ However, this threshold was obtained in a general population, and our data as well as those of others²⁰ suggest that a larger threshold must be considered for vertebral fracture screening in a population of postmenopausal osteoporotic women aged between 65 and 85 years. These discrepancies may be related to the uncertainty of the reference value—that is, the height at age 25 years estimated by the patient herself.

Our results apply only to patients with back pain, which is a frequent cause for consulting a doctor. The question of the necessity for spine radiography has been previously raised in a general population of postmenopausal women. Vogt *et al*¹⁴ suggested that a simple index using 5 parameters (history of vertebral fracture, history of non-vertebral fracture, age, height loss, and diagnosis of osteoporosis) is a relevant tool to justify

Table 4 Scoring index for prediction of vertebral fracture

1—Age (years)	
<65	0
65–69	1
70–74	2
75–79	3
≥ 80	4
2—Intensity of back pain	
<65 mm on VAS	0
≥ 65 mm on VAS	2
3—Height loss (cm)	
<3	0
3–6	2
≥ 6	4
4—History of low-trauma non-vertebral fracture	
Yes	1
No	0
5—Sudden occurrence of pain	
Yes	4
No	0
6—Thoracic localisation of pain	
Yes	1
No	0

VAS, visual analogue scale.

spine radiography. In EPOS, the risk of prevalent vertebral fracture was increased with age, height loss and history of vertebral and peripheral fractures; use of this information in a screening procedure optimised the selective use of spine radiography.¹⁵ The positive predictive value of our index (70.9%) is higher than that reported in the EPOS study (38% for a given prevalence of 26%);¹⁵ this difference can be explained by both a higher prevalence of vertebral fractures in our population (50%), and our careful assessment of characteristics of pain, as expected in a clinical study.

We fully recognise the limitations of our study. BMD was not used in the index as this parameter was not obtained during the same period for all patients, and was not controlled in a central facility. Further studies should assess the role of this measurement in the predictive value of this index. Moreover, the sample size is low and validation of our scoring system in another population is necessary.

Among postmenopausal women with osteoporosis consulting for back pain, the results presented here can be useful in helping doctors make decisions about the need for spinal radiography, in their search for treatment.

ACKNOWLEDGEMENTS

We acknowledge Frédérique Maurel, Camille Reygrobellet and Professor Claude Le Pen (AREMIS) for their contribution to statistical analysis and interpretation. We thank all the EMERAUDE study investigators for their participation in the study. We also thank Stephanie Jones for her help in the manuscript preparation.

Authors' affiliations

C Roux, J Fechtenbaum, Université Paris-Descartes, Hôpital Cochin, Paris, France

G Priol, AREMIS, Paris, France

B Cortet, Service de Rhumatologie, CHU Lille, France

S Liu-Léage, Laboratoire Lilly, Suresnes, France

M Audran, Pôle ostéo-articulaire; EMI-INSERM 0335 CHU, Angers, France

Competing interests: None declared.

REFERENCES

- 1 Cummings SR, Melton LJ III. Epidemiology and outcomes of vertebral fractures. *Lancet* 2002;**359**:1761–7.

- 2 Kotowicz MA, Melton LJ, Cooper C, Atkinson EJ, O'Fallon WM, Riggs BL. Risk of hip fracture in women with vertebral fracture. *J Bone Miner Res* 1994;**9**:599–605.
- 3 Klotzbuecher CM, Ross PD, Landsman PB, Abbott TA III, Berger M. Patients with prior fractures have an increased risk of future fractures: a summary of the literature and statistical synthesis. *J Bone Miner Res* 2000;**15**:721–39.
- 4 Oleksik A, Lips P, Dawson A, Minshall ME, Shen W, Cooper C, et al. Health related quality of life in post menopausal women with low BMD with or without prevalent vertebral fractures. *J Bone Miner Res* 2000;**15**:1384–92.
- 5 Cockerill W, Lunt M, Silman AJ, Cooper C, Lips P, Bhalla AK, et al. Health-related quality of life and radiographic vertebral fracture. *Osteoporos Int* 2004;**15**:113–9.
- 6 Ensrud KE, Thompson DE, Cauley JA, Nevitt MC, Kado DM, Hochberg MC, et al. Prevalent vertebral deformities predict mortality and hospitalization in older women with low bone mass. *J Am Geriatr Soc* 2000;**48**:241–9.
- 7 Cauley JA, Thompson DE, Ensrud KC, Scott JC, Black D. Risk of mortality following clinical fractures. *Osteoporos Int* 2000;**11**:556–61.
- 8 Huang C, Ross PD, Washnich RD. Vertebral fracture and other predictors of physical impairment and health care utilization. *Arch Intern Med* 1996;**156**:2469–75.
- 9 Nevitt MC, Ettinger B, Black DM, Stone K, Jamal SA, Ensrud K, et al. The association of radiographically detected vertebral fractures with back pain and function: a prospective study. *Ann Intern Med* 1998;**128**:793–800.
- 10 Gunnes M, Lehmann EH, Mellstrom D, Johnell O. The relationship between anthropometric measurements and fractures in women. *Bone* 1996;**19**:407–13.
- 11 Deyo RA, Weinstein JN. Low back pain. *N Engl J Med* 2001;**344**:363–70.
- 12 Huang C, Ross PD, Wasnich RD. Vertebral fractures and other predictors of back pain among older women. *J Bone Miner Res* 1996;**11**:1026–32.
- 13 Spector TD, McCloskey EV, Doyle DV, Kanis JA. Prevalence of vertebral fracture in women and the relationship with bone density and symptoms: the Chingford study. *J Bone Miner Res* 1993;**8**:817–22.
- 14 Vogt TM, Ross PD, Palermo L, Musliner T, Genant HK, Black D, for the Fracture Intervention Trial Research Group, et al. Vertebral fracture prevalence among women screened for the Fracture Intervention Trial and a simple clinical tool to screen for undiagnosed vertebral fractures. *Mayo Clin Proc* 2000;**75**:888–96.
- 15 Kaptoge S, Armbrecht G, Felsenberg D, Lunt M, O'Neill TW, Silman AJ, on behalf of the EPOS Study Group, et al. When should the doctor order a spine X-ray? Identifying vertebral fractures for osteoporosis care: results from the European Prospective Osteoporosis Study (EPOS). *J Bone Miner Res* 2004;**19**:1982–93.
- 16 Genant HK, Wu CY, Van Kuyk C, Nevitt MC. Vertebral fracture assessment using a semi-quantitative technique. *J Bone Miner Res* 1993;**8**:1137–48.
- 17 Mickey R, Greenland S. The impact of confounder selection criteria on effect estimation. *Am J Epidemiol* 1989;**129**:125–37.
- 18 Black DM, Steinbuch M, Palermo L, Dargent-Molina P, Lindsay R, Hoseyni MS, et al. An assessment tool for predicting fracture risk in post menopausal women. *Osteoporos Int* 2001;**12**:519–28.
- 19 Kanis JA, Minne HW, Meunier PJ, Ziegler R, Allender E. Quality of life and vertebral osteoporosis. *Osteoporos Int* 1992;**2**:161–3.
- 20 Siminoski K, Warshawski RS, Jen H, Lee K. The accuracy of historical height loss for the detection of vertebral fractures in post menopausal women. *Osteoporos Int* 2006;**17**:290–6.