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Vertebral Geometry Parameters Can Predict Fractures

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Abstract

Background: The aim of this study was to investigate vertebral geometry changes and determine cutoff value of vertebral height to predict fractures.
Methods: In a cross-sectional study, 280 postmenopausal women recruited .In all subjects bone mineral density and radiography of the lumbar spine performed. Lateral radiographs were evaluated for identification of vertebral fractures, using a validated semiquantitative method. T-score of vertebral height was calculated based on data extracted from Iranian Multicenter Osteoporosis Study. ROC curve used to determine cut off value of vertebral height T-score to predict fractures.
Results: The mean of age and BMI were 55.34±8.7 years and 27.73±5 kg/m2, respectively. Among osteoporotic women, 59.8% had one or more vertebral fractures and 23.8% had at least 2 fractures. In fracture group the T-score of spine and femur BMD was lower than the others. The mean of vertebral height in women without fractures was 12.94±0.6 cm, and in the patient with 4 or more fractures was12.3, thus every fracture accompany with 1.2% decreases in the height of vertebrae. The prevalence of vertebral fracture in osteoporotic patients was 71.4% and in healthy cases 39.5%. Better estimation of vertebral height T score in ROC curve was less than -0.7.The sensitivity and specificity of the cut off value were 81.3% and 52.9%, respectively.
Conclusion: Vertebral fractures are common fractures in postmenopausal women. There was a correlation between vertebral height and fractures. Vertebral geometric parameters especially height T score can be used for fracture screening.

Keywords: *Vertebral geometry, Fracture, BMD, Radiography*

Introduction

Fractures of the spine are the most common type of osteoporotic fractures (1), occurring in ~20% of postmenopausal women (2). However, three-fourths of vertebral fractures do not come to immediate clinical attention, the so-called “clinically silent” vertebral fracture (3). The low identification rate of these vertebral fractures should be of concern because they are associated with increased risk of future vertebral and hip fractures even after adjusting for the effects of known major risk factors for fracture such as age, weight, and BMD (4). Indeed, postmenopausal women with at least one vertebral fracture have a 5-fold increased risk of sustaining another vertebral fracture within the coming year (3) and a 2-fold increased risk of other fragility fractures, including hip fractures (4). In addition, patients with vertebral fracture have poor scores on health-related quality-of-life measures (5-7) which in turn, may predispose to other co-morbid conditions and increase death rates (8-10) and the health and economic burden associated with vertebral fracture. Height loss, kyphosis, chronic back pain, and back-related functional disability result when vertebral fractures remain untreated (11-13).
With the number of aged people at risk for osteoporosis expected to increase dramatically in the next decades, accurate identification and treatment intervention of patients is necessary to reduce the enormous potential impact of this disease on patients and health care systems (14).
The standard methodology for diagnosing vertebral fracture is a radiologist’s qualitative evaluation of vertebral X-ray films. Over the years, advances have been made in imaging technology and there are new methods for evaluating X-

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rays, including the use of semiquantitative grading scales and morphometry (15).
Despite the knowledge of the risk factors, little progress is evident in translating findings into an effective diagnostic tool that can be useful in primary care for making objective decisions on whom should have an X-ray to confirm (or exclude) the presence of prevalent vertebral fracture (1). Currently, this is frequently a mandatory first step in making treatment decisions.
Currently, there are wide variations in national strategies for identifying cases of osteoporosis for treatment, varying from BMD screening in the >65 yr group (United States) (16) to case finding (United Kingdom) and densitometry offered to those who already have suffered an identified fracture (some other European countries). These strategies all partially fail to identify patients deserving of treatment, particularly if they have vertebral fractures, although in the United States, it seems that the more severe case whose first fracture occurs before age 65 is at most risk (1).
Screening of osteoporosis is based on the measurement of BMD. But femoral neck BMD (17, 18) and spine BMD (19) have been recently reported not to be significantly different for hip or vertebral fractures. This indicates that in both types of osteoporosis (post-menopausal (type one) and senile (type two) bone loss is a generalized phenomenon and supports the concept that other risk factors are needed to determine the different types of fracture (20, 21). This is also strengthened by the fact that some proximal femur geometry parameters (PFG) have also been shown to be associated to hip fracture risk in osteoporotic subjects (22-24). Few studies of this kind were done on vertebral geometries, so the ability of vertebral geometric parameters to screen vertebral fractures should be further ves-tigated to better understand their specificity for these kinds of fractures. Therefore, by using geometric factors there may be a new way to screen vertebral fractures and order X-ray.
Our objective was to improve the screening method and evaluating vertebral geometry and determine a reliable cut off for which the BMD's geometry may suggest fractures.

Materials and Methods

In a cross-sectional study, 280 women attended the BMD unit of Endocrinology & Metabolism Research Center (EMRC) of Tehran University of Medical Sciences, Iran was recruited. The women were selected consecutively if they fulfilled the criteria and if they were willing to participate in the study. All patients gave informed consent, and the study was approved by Research Ethics Committee.

Questionnaire The questionnaire administered at baseline contained questions on demographics, medical history, fracture history, gynecological information, physical activity, and lifestyle variables. To assess fracture history, participants were asked if they had ever suffered from a broken bone, and if so, to give details on which bone, age at first fracture, and level of trauma experienced. The fracture type choices given were vertebral, hip, rib, forearm, and other

Spinal radiography Radiograph images were taken by a professional X-ray technician using standard, proven safety precautions. Lumbar radiographs in the antero-posterior and left lateral projections were acquired following a standardized protocol (25). For the lateral views, subjects were positioned in their left side with knees and hips flexed. Tube-to-film distance was set at 115 cm and films were centered at L3 for lumbar views. The spinal radiographs were assessed independently by two expert observers (who were both medically qualified) for evidence of osteoporotic vertebral fracture.

BMD measurements Using DPX Lunar, postero-anterior scans of the lumbar spine (from L1 to L4) and left hip were also acquired to measure BMD. On the basis of their bone mass, patients were classified as normal, osteopenic or osteoporotic, according to the WHO criteria (26). T-score of vertebral height was calculated.

Visual semiquantitative assessment (SQ)
Conventional radiographs were examined first for quality and then for fractures by an experi-

enced radiologist. According to Genant et al. (27), reductions in the anterior, middle or posterior vertebral heights were classified as mild (20-25% reduction), moderate (25-40% reduction), or severe (>40% reduction).

Statistical analysis Data were analyzed by means of a personal computer implemented with dedicated software (SPSS 11.5), to obtain mean±SD values, correlation matrix, Student's *t*- and/or χ^2 tests, as appropriate. The level of significance was settled at < 5%, as usual. Moreover, to evaluate the agreement between the three techniques, we calculated the concordance index (28). ROC curve used for determine the cut off value of vertebral height T-score to predict fractures.

Results

Two hundred eighty one postmenopausal women were recruited. The characteristics of participants are summarized in Table1. In X-ray study 59.8% of participants had at least one fracture. Distribution of fractures in lumbar vertebrates is shown in Fig. 1.

There were no significant differences as for age, menarche and menopause age and BMI between women with and without fractures. In fractured group the BMD t-score of spine and femur was lower in comparison with women without fractures (Table2).

In Fig. 2 the relationship between the decrease of spinal T-score BMD and fractures is shown.

The mean of vertebral height in the women without fractures was 12.94±0.6 cm and in women with four fractures was 12.32±0.6cm, based on this calculation vertebral height was decreased 1.2% per each fractures.

There was a significant correlation between vertebral height and age (*P*= 0.001, r=-0.34) height (*P*= 0.001, r= 0.67) and spine t-score (*P*= 0.003, r= 0.18).

The prevalence of vertebral fractures in osteoporotic patients was significantly higher than others (74.1 % vs 27.8%, *P*= 0.005).

In regression model, age and BMD had an independent relationship with vertebral height (*P*=0.001 and *P*= 0.03, respectively) but there was no independent relation between vertebral height and age (*P*= 0.1). In ROC curve, evaluation of vertebral height T score to screen fractures show that 0.7 decreases in T score of height is the best cut off point to predict fractures. (Fig. 3). The sensitivity and specificity of this cut off value were 81.3% and 52.9%, respectively.

Table1: The characteristics of 280 women attended the BMD unit of Endocrinology & Metabolism Research Center of Tehran University of Medical Sciences

variables	Mean± SD
Age(yr)	53.34±8.7
Menopause(yr)	46.17±6.8
Menarch(yr)	13.4±1.4
Height(cm)	57.53±5.9
Weight(kg)	9.1±13.7
BMI(kg/m^2)	27.7±5
Spine T-score	-1.37±1.5
Femur T-score	-0.7±1.2

Table 2: The characteristic of participant in fracture and non-fracture group

Groups / variables	Total participants	With fracture (Mean±SD)	Without fracture (Mean±SD)	*P*
Age(yr)	53.34±8.7	56.6±8.8	54.8±8.4	0.2
Menopause(yr)	46.17±6.8	46.9±5.5	44.5±9.9	0.1
Menarche(yr)	13.4±1.4	13.4±1.4	13.4±1.4	0.8
T-score of spine	-1.37±1.5	-1.8±1.3	-0.9±1.6	0.0001
T-score of femur	-0.7±1.2	-1.1±1	-0.2±1.3	0.0001
BMI(kg/m^2)	27.7±5	27.5±5.4	28.2±4.6	0.4

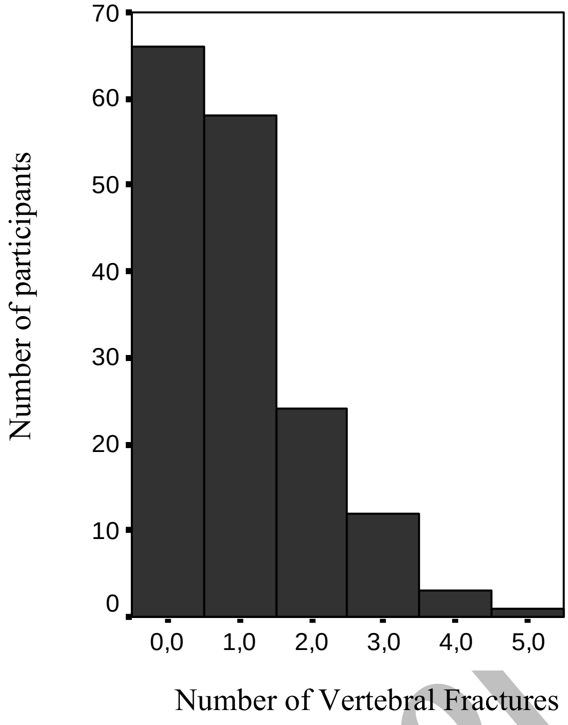

Fig.1: Distribution of fractures in lumbar vertebrates

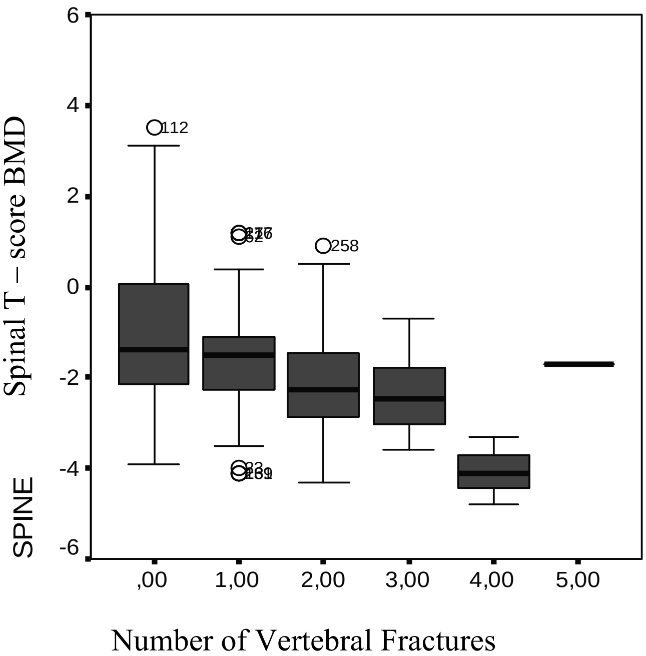

Fig. 2: Relationship between the decrease of spinal T-score and fractures

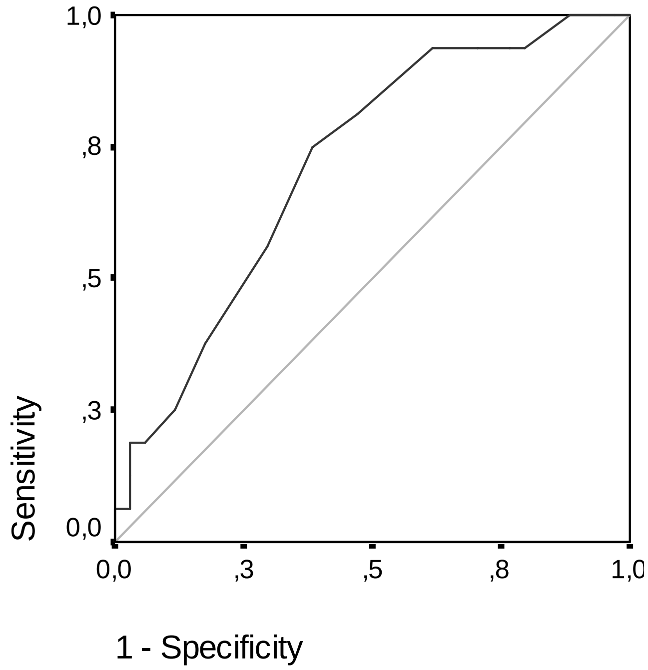

Fig. 3: Fracture prediction based on vertebral height T-score by Roc Curve

Discussion

Vertebral fracture is the commonest fracture in postmenopausal women. Once an initial vertebral fracture is sustained, the risk of subsequent vertebral fracture increases significantly. Our results show that the prevalence of vertebral fracture was 59.8% in sample group. The prevalence of vertebral fractures in cohorts of similar age varies according to other studies (29-31). There are several potential sources of this variability. Differences may be due to true differences in the prevalence of vertebral fractures between populations (32, 33).

In a study conducted by Ling et al. in China the prevalence of vertebral fracture in the age group of 50-59, 60-69 and 70-79 yr was 3.9%, 10.5% and 15 %, respectively (34). Whereas in a study Rochester, USA the prevalence of vertebral fracture in the 70-79 yr age group was 22% (35).

In another study on 481 Chinese women aged 70-79 yr, the prevalence of vertebral fracture was 29% (36). The diagnosing method of vertebral fracture was the same as an American study where the prevalence of vertebral fracture was 25 %.

Review of data from medical care surveys have indicated that only 2-12% of people with radiologically evident spine fracture(s) are identified in British primary care health services (37, 38). In our study a non of the participant was aware of their fractures.

In our study there was a significant correlation between vertebral height and age, height and spine t-score BMD. In our study prevalence of vertebral fractures in osteoporotic patients was significantly higher than others (74.1% vs 27.8%, *P*= 0.005). Sone et al. in a study of 479 Japanese women (aged 53.9+/-9.1 yr) found that aged-related decreased in vertebral height ratios (Ha/Hp and Hm/Hp, each averaged from T12 to L4) was significant even after the correction for BMD (39).

A strong relation exists between BMD measured by dual energy x ray absorptiometry (DXA) and the risk of fracture (40). Fracture risk increases with decreasing BMD, so that there is no exact cut off point to characterize absolutely a person who will fracture from one who will not (41).

In our study T-score of spine and femur (BMD) in fracture group was lower in comparison with women without fractures; which is in consistent with other studies (42).

Abrahamsen et al. reported that the risk of fracture increased by 1.30 (95% CI, 1.06; 1.58) for each unit decrease in lumbar spine T- score at baseline (43). In a study conducted by Sahota et. al. they recruited 150 early postmenopausal women, and reported that of all four vertebrae, L2 had the highest T-score in 37.7% of the subjects (mean -0.3) and L4 the lowest in 61% (mean -1.5) (mean difference 1.2 units, 95% CI 0.7 to 1.7) (39). They also mentioned that individual T-scores of the lumbar vertebrae show wide variation in the absence of degenerative spinal disease or vertebral collapse and the use of the lowest, significantly different, individual lumbar vertebra T-score reclassified over half of the subjects in their study. That poses a great therapeutic dilemma in clinical practice, particularly if these fractures are at higher risk of future collapse (43, 44).

Kaptoge et al. showed that in a negative binomial regression model without baseline X-ray data, the risk of incident vertebral fracture significantly increased with age [RR 1.74, 95% CI (1.44, 2.10) per decade], height loss [1.08 (1.04, 1.12) per cm decrease], female sex [1.48 (1.05, 2.09)], and recalled fracture history; [1.65 (1.15, 2.38) to 3.03 (1.66, 5.54)] according to fracture site. Also age, sex and height loss remained independently predictive (45).

Several studies have investigated age-related changes in vertebral shape (37,46,47). Two were prospective studies following women over a 10- to 20-year period from pre- to post menopause. Neither found any significant decrease in vertebral dimensions with increasing age (37, 47). Conversely, all four cross-sectional studies identified significant decreases of some kind in vertebral heights and ratios (47, 48).

The significant relation between vertebral height and age has been shown in a study in which there was a decrease in height of vertebrae in L2-L4 (49). Decrease of vertebral height could cause decrease total body height. Moayyeri et al. found that after adjustment for age, gender, and weight, height loss remained a significant predictor for femoral neck T-score (beta=-0.078; P= 0 .043) (50).

The presence of at least one spine fracture will lead to about a 2 cm decrease in height. Guidelines in the US say that height loss greater than 1.5 inches or more from the maximum height among asymptomatic women may be associated with osteoporotic vertebral compression fractures (51).

Salimzadeh et al. reported that the correlation of the total spine height average with age was not significant (P> 0.05), but it correlated fairly well (r= 0.47, P< 0.05) with stature (52).

In our study, evaluations of vertebral height T-scores to screen fractures show that at least 0.7 decreases in T-score is the best cut off point to predict fractures. This finding is in consistent with other studies. From the methodological point of view, differences of the estimated fracture thresholds can be related to different diagnostic criteria (53, 54), real differences of the shape of vertebral bodies (55, 56), and different approaches to define normal reference values.

Siminoski et al. show that there is a strong relationship between the amount of height loss and the risk of a new vertebral fracture. While there is no cut-off that can reliably rule in a new fracture, height loss of < or= 2.0 cm over 1-3 years has acceptable accuracy for ruling out an incident fracture (57).

Although new BMD instruments provide vertebral assessment to evaluate geometric parameters, the old instruments replacement in developing country may not be cost beneficial .Thus use of geometric parameters in a simple model can be practical to screen vertebral fractures.

In conclusion the vertebral height can be used for fracture screening even in BMD imaging.

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