

Brief Report

Validity of Bone Mineral Density and WHO Fracture Risk Assessment Thresholds in Hip Fractures

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Abstract

Hip fractures are common and serious consequence of osteoporosis. Bone mineral density (BMD) measurement and the World Health Organization (WHO) fracture risk assessment tool are considered to predict the hip osteoporotic fractures. In this study, their sensitivities in hip fracture cases are evaluated. BMD and WHO probability of fracture risk were determined in 71 hip fractures ≥ 50 years of old. Totally, 65% of patients had ≤ -2.5 BMD T score. 81% of patients had above the upper interventional threshold of WHO fracture risk probability model. Sensitivities were low in 50 – 59 year age group with progression in older age groups. Results of BMD T score and fracture risk probabilities were not significant between men and women. There were 23% and 49% sensitivities of less than or equal to -2.5 T score in the 50 – 59 and 60 – 69 year age groups with a 31% sensitivity of greater than 3% probability of hip fracture risk in the 50 – 59 year age group, both of which were not valid for predicting hip fracture risk.

Keywords: BMD T score, fracture risk assessment threshold, sensitivity, ≥ 50 year old hip fracture

Introduction

Osteoporotic fractures occur at multiple skeletal sites, mostly the spine, hip or wrist, and affect up to one-half of women and up to a third of men aged over 50 years. Hip fractures are common and serious consequences of osteoporosis. The total number of hip fractures worldwide has been estimated at 1.7 million in 1990, and is projected to climb to 6.3 million in 2050. The number of men and women with disabilities directly related to these fractures has reached epidemic proportions. Approximately 50% of women who sustain a hip fracture lose the ability to walk normally and mortality is increased 20% during six months after the fracture. Patients presenting with an osteoporotic related hip fracture are at increased risk of a second hip fracture.¹ The lifetime risk of sustaining an osteoporotic fracture has been estimated at 50%, compared with 9% for breast cancer and 31% for coronary artery disease.²

Several concepts have been emerged regarding the risk of osteoporotic fractures. The primary culprit is poor bone mineral density (BMD). According to the World Health Organization (WHO) 1994 guidelines, osteoporosis is defined as a BMD that lies 2.5 standard deviations (SD) or more below the average value for young healthy women (T-score of ≤ -2.5 SD). This criterion provides both a diagnostic and intervention threshold.³ But fracture prediction based only on BMD tests is inadequate and application of independent factors of fracture risk makes it more precise. Fracture risk is commonly expressed as a relative risk which has different meanings in different contexts. The risk of fracture depends upon age and life expectancy. Remaining lifetime risk of fracture increases with age up to 70 years. Thereafter it plateaus and then decreases, since the risk of death with age outstrips the increasing incidence of fracture with age. For this reason, in 2000 the WHO

has recommended that relative risk of fracture should be expressed as an absolute risk-probability over ten years to identify patients who require treatment.⁴⁻⁶

In 2008, WHO has developed a fracture risk assessment tool (FRAX) to identify the ten year probability of hip fracture or a major osteoporotic fracture (clinical spine, forearm and shoulder). Epidemiological studies have been carried out following fracture risk factors each of which is sufficient to decrease bone strength and cause fracture after a minor trauma, including age, sex, height, weight, body mass index (BMI), prior fragility fracture after age 50, history of corticosteroid use, rheumatoid arthritis, secondary osteoporosis, current smoker, alcohol use and BMD.⁷ Integrations that impact fracture risks without BMD are being determined. Men and women with probabilities below the lower assessment threshold could be reassured. Individuals with probabilities above the upper threshold should be assessed for treatment. Those with probabilities between the lower and upper limits should be considered for testing with BMD using dual energy X-ray absorptiometry to improve the estimation of fracture risk. Their probabilities would be recomputed with BMD and treatment decision subsequently made if fracture probabilities lie above the interventional threshold (Figure 1).⁸

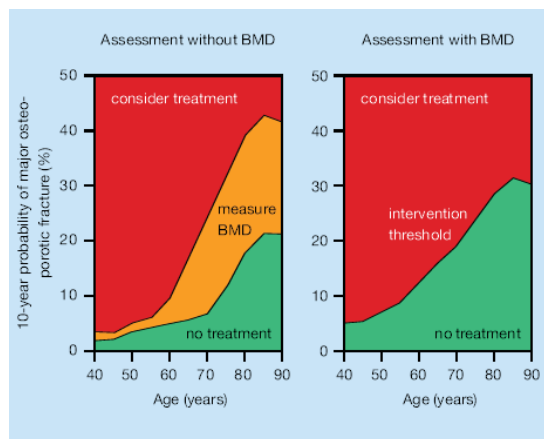


Figure 1. Treatment thresholds according to 10-year osteoporosis fracture risk and age.

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Table 1. Sensitivity of the BMD T score and fracture risk probability in hip fracture cases.

Age group	Number	Total hip T score ≤ -2.50	Probability of hip fracture risk $>3\%$ interventional threshold
59-50	13	23%	31%
69-60	12	49%	84%
79-70	33	79%	91%
89-80	13	91%	100%
total	71	65%	81%

Table 2. Sensitivity of the BMD T score and fracture risk probability in fracture types.

Fracture type	Number	Total hip T score ≤ -2.5	Probability of hip fracture risk $>3\%$ interventional threshold
Trochanteric	52	65%	78%
Mid- and base cervical	4	50%	0%
Subcapital	15	60%	80%

In this study, we determined the BMD T score and fracture risk probability in hip fracture cases and compared them with interventional thresholds to evaluate the sensitivity of FRAX.

Patients and Methods

This cross-sectional study was performed in Urmia University of Medical Sciences. Patients 50 years and older with hip fractures admitted to the Orthopedics Department from September, 2005 until January, 2007 participated in this study. All fractures resulted from low energy traumas such as falling. Exclusionary criteria were: previous hip fracture, precedent evaluation or treatment of osteoporosis, acute medical complications that required intense care, long term steroid therapy, paralytic and bedridden patients. In 71 patients, the total hip and L2-L4 BMD levels were measured with a Hologic ODR Dual Energy X-ray Absorptiometry device, 2 – 4 weeks following discharge in the Outpatient department clinic. The coefficient variation of the device was maintained at less than 1.1% with company warranty services.

Only hip BMD is detected in fracture risk assessment. The necessary prerequisite for the development of a FRAX tool in any country is information on the epidemiology of the fracture and death. The most complete models available are from England, Sweden, Japan and the USA since epidemiology of the relevant fractures are established.^{9,10} In France, Spain, Italy, China and Turkey, FRAX models are solely based on hip fracture risk and the relevant risk functions for other major fractures are derived. The application of these models to Iran, which is not yet accommodated in FRAX is difficult.

Results of tests from several countries have assumed that the ratio of hip fracture incidence to age, sex and incidence of other risk factors are same as Sweden. Thus, as with many other countries we used the Sweden model,¹¹ which was the main limitation of this study. We also calculated the hip fracture risk by using the Poland Osteoporotic Foundation manual algorithm with the same results.¹² Student *t*-test was used to determine significance between men and women.

Results

The 71 subjects were stratified into four 10-year age groups: 50 – 59 years (10 males, 3 females); 60 – 69 years (4 males, 8 females); 70 – 79 years (17 males, 16 females); and 80 – 89 years (9 males, 4 females). Totally, 40 patients (55%) were male and 31 (45%) were female. Trochanteric fractures consisted of 74% of cases, whereas 6% were mid- and base cervical, and 21% were subcapital.

In regards to the osteoporotic level of BMD, 65% of the patients

scored less than or equal to -2.5 T. There was no significant difference between men and women ($P=0.6$).

Based on the WHO case finding strategy to prevent hip fracture with greater than 3% interventional threshold, 81% of the patients in this study would be screened for treatment prior to the onset of a fracture. There was no significant difference between men and women ($P=0.1$). Fifty to 59 years age group had the lowest rate of sensitivity, which was growing in the following age groups Table 1. Overall, 15% of subjects with T scores greater than -2.5 and hip fracture probability less than 3% suffered a hip fracture without major trauma.

In regards to fracture type, T score levels less than or equal to -2.5 and the probability of hip fracture risks greater than 3% are presented in Table 2.

Discussion

Available data in men and women relating bone density to fracture risk has been obtained from the third National Health and Nutrition Examination Survey (NHANES III) references based on Caucasian women aged 20 – 29 years.¹³ From these studies it has been determined that direct measurements of the hip are the most sensitive predictors of hip fracture. Heel measurements have also been shown to be excellent for predicting hip fracture. Lumbar BMD values are unreliable. It is believed that degenerative bone change influences spinal measurements in the elderly by falsely elevating BMD measurement, which results in fracture risk underestimation.¹⁴ This fact was confirmed in women of this study with ascending L2-L4 BMD that corresponded to age. Males had descending lumbar values, parallel to hip BMDs with aging (Figure 2).

A low BMD T score is an important risk factor for fractures. Hip fracture prediction with BMD alone is at least as good as blood pressure readings to predict stroke, however there are problems with the use of BMD T scores alone for the detection of individuals at high risk for fractures. This test has high specificity but low sensitivity.

Using a standard definition of osteoporosis (T score less than or equal to -2.5), approximately 50% of all fractures would be missed because they occur in subjects who have a BMD T score in the osteopenic or normal range, with significant overlap.^{15,16} In our study, this result is compatible with 23% of the 50 – 59 and 49% of the 60 – 69 year age groups. However, with ascending age, increase in sensitivity was seen. There were 79% of the 70 – 79 year and 91% of the 80 – 89 year age groups who had T scores less than or equal to -2.5.

WHO has considered a greater than 3% fracture risk probability as the interventional threshold for hip fracture alone. This thresh-

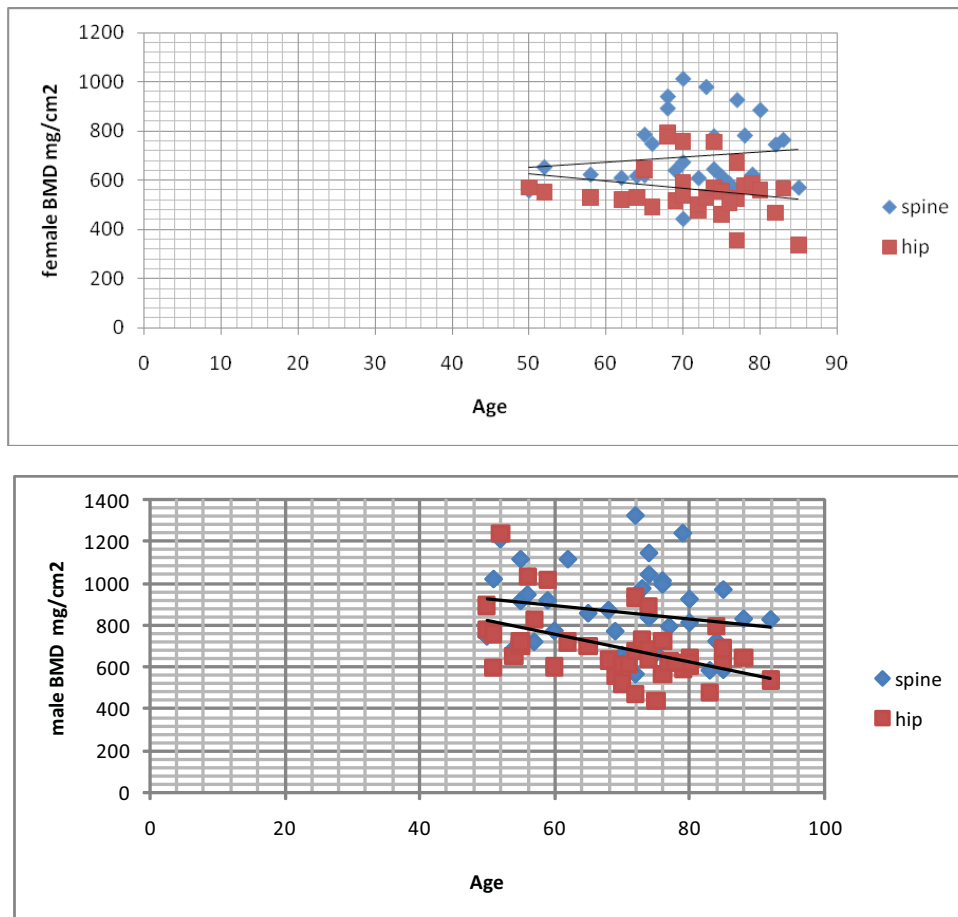


Figure 2. Spine and total hip BMD in patients with hip fractures.

old screened 31% of 50 – 59 group, 84% of the 60 – 69, 91% of the 70 – 79 and 100% of the 80 – 89 year groups, and totally, 81% of patients in this study for treatment. It seems that the weight of factors for fracture risk was insufficient to characterize osteoporotic hip fracture in the 50 – 59 year age group; therefore the burden of a greater than 3% treatment threshold was not reliable in case finding strategy.

In conclusion, there were 23% and 49% sensitivities of less than or equal to -2.5 T score in the 50 – 59 and 60 – 69 year age groups with a 31% sensitivity of greater than 3% probability of hip fracture risk in the 50 – 59 year age group, both of which were not valid for predicting hip fracture risk.

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