Evaluation of the Discrepancy in Bone Mineral Density Between the Lumbar Spine and Femoral Neck Among Japanese Women According to Age

Gynecology and Women's Health Care

Research Article

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Submitted : 28 Oct 2020 ; Published : 15 Nov 2020

Abstract

This study aimed to examine the age-specific individual discrepancy between lumbar spine (LS) bone mineral density (BMD) and femoral neck (FN) BMD in Japanese women and to compare the significantly different characteristics between the two bone sites. We found a higher prevalence rate of discordance between the two BMD T-score sites, and many patients had a lower LS BMD T-score than FN BMD T-score. We believe that our study makes a significant contribution to the literature because our findings suggest that physicians should assess BMD more carefully in women who have a low body weight or body mass index and parental hip fracture history. For these patients, it is necessary to measure both the LS and FN BMD T-scores for calculating the fracture risk.

Introduction

Osteoporosis causes an increased risk of fractures. In Japan, the number of individuals with osteoporosis has increased to 1070 million, and 80% are women [1]. Osteoporosis is associated with aging, and its incidence is increasing annually with the prolonged life expectancy [2]. Fragility fractures affect the general aspects of life, significantly lower the quality of life, and are associated with substantially higher mortality [3,4].

Evaluating the risks of fracture in individual patients, such as a history of fragility fracture, smoking, steroid use, and family (parents') history of existing fractures, is necessary. Quantitative assessments of the fracture risk using risk factors were first developed in the 1990s [5]. In 2004, the World Health Organization proposed the Fracture Risk Assessment Tool (FRAX®), which calculates the 10-year probability of major osteoporotic and hip fractures [6]. FRAX® estimates the fracture risk by assessing risk factors such as age, sex, body weight, height, history of fragility fracture, family history of hip fracture, alcohol use (3 or more units/day), current smoking habits, glucocorticoid use, rheumatoid arthritis, and femoral neck (FN) bone mineral density (BMD). FRAX® is valuable to physicians because it aids them in making appropriate decisions concerning osteoporosis treatment.

Other methods for fracture risk assessment have also been proposed, including Pleskiesicz's algorithm [7] and the Garvan algorithm [8], because these authors did not believe in the usefulness of FRAX® [7]. Nguyen et al. developed the Garvan algorithm to predict the 5-year risk of hip fracture using the patient's history of steroid use, falls, fractures, FN BMD T-score, and height [8].

The FN region is widely regarded as the optimum site for diagnosing osteoporosis and assessing the fracture risk. It has good predictive value for osteoporotic fractures because the lumbar spine (LS) BMD is often spuriously increased by degenerative changes [9]. Therefore, the FN T-score is the only validated measurement for calculating the fracture risk [10].

When diagnosing osteoporosis, discordance refers to the differences in the BMD across the bone sites, and the diagnosis can change according to the bone sites that are used for measuring BMD [11,12]. BMD is primarily measured at the LS and FN, and osteoporosis at each site has been reported previously [12-15]. Numerous studies have suggested that BMD should be measured at multiple sites, whereas others recommend using FN as the BMD reference site for diagnosing osteoporosis [16-18]. For patients with significant differences between the FN and LS T-scores, FRAX® is less accurate for predicting the vertebral fracture risk [2,19,20]. However, it is unclear how to address T-score discordance when the LS T-score is lower than the FN T-score [21]. If discrepancies between the LS BMD and FN BMD exist, then physicians cannot accurately assess the risk of fractures. Therefore, we examined

age-specific individual discrepancies between LS BMD and FN BMD of Japanese women and compared the characteristics that were significantly different between the two bone sites.

Materials and methods

Study design and population

For this retrospective study, we recruited 292 women aged 50 to 79 years who underwent valid LS BMD, TH BMD, and FN BMD assessments between January 2005 and February 2016. Patients were excluded if they had undergone bone-specific treatment or hormone replacement therapy. This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by institutional review board of Tokyo women's medical university (approval number: 4647). Informed consent was obtained from all patients during medical examination or by telephone prior to their inclusion in this study.

BMD Measurements

BMD was measured using dual X-ray absorptiometry (DXA) (Hologic QDR 4500; Hologic Inc., Waltham, MA, USA). We used the mean LS BMD value from at least three evaluable vertebrae from L1 to L4. LS BMD, total hip (TH) BMD, and left FN BMD of all patients were measured on the same day. We classified the patients into four groups based on the TH BMD, FN BMD T-score, and LS BMD T-score; a T-score ≤-2.5 was considered a decrease in BMD.

Group 1 (G1) included patients with non-osteoporotic LS BMD, TH BMD, and FN BMD T-scores; group 2 (G2) included those with decreased LS BMD T-scores; group 3 (G3) included those with decreased TH or FN BMD T-scores; and group 4 (G4) included those with decreased LS BMD and TH or FN BMD T-scores. We included FN BMD T-scores because when we used only FN T-scores, the scores of G2 were very low.

Characteristics and Clinical Risk Factors

Age was defined as the age when DXA was performed, and weight and height were recorded when the DXA examination was performed. Assessments of the fracture history and family history of hip fracture were based on medical interviews. Clinical risk factors, menopausal years, and history of steroid use were confirmed during the interview.

Statistical Analysis

Data are shown as the mean ± standard deviation (SD). We compared the dominant differences between G1 and G2, between G1 and G3, and between G2 and G3. We used the Mann-Whitney test to compare the patient characteristics and categorical data. The Fisher exact test was used to compare the clinical risk factors. All statistical analyses were performed using JMP® 13 (SAS Institute Inc., Cary, NC, USA).

Results

The distribution of patients per group is shown in Table 1. There were more patients in their 50s (12.9%), 60s (10.8%), and 70s (19.6%) in G2 than in the other groups. Therefore, we compared the dominant differences between G1 and G2, between G1 and G3, and between G2 and G3.

Age	G1	G2	G3	G4	Total
50s	108	18	6	7	139
60s	73	11	9	9	102
70s	24	10	8	9	51
Total	205	39	23	25	292

Table 1: Distribution of patients per group

G1 non-osteoporotic group,

G2 group with decreased lumbar spine bone mineral density T-scores,

G3 group with decreased femoral neck or total hip bone mineral density T-scores,

G4 group with decreased lumbar spine bone mineral density and femoral neck or total hip bone mineral density T-scores

[a]G2 included more patients in their 50s (12.9%), 60s (10.8%), and 70s (19.6%) than other groups.

The comparison of the characteristics of G1 (n = 205) and G2 (n = 39) is shown in Table 2. Significant differences in height (P = 0.0294), weight (P = 0.0045), LS BMD T-scores (P<0.0001), FN BMD T-scores (P <0.0001), TH BMD T-scores (P = 0.0115), FRAX® scores for vertebral fracture risk (P = 0.0560), FRAX® scores for FN fracture risk (P = 0.0002),Garvan algorithm results for 5-year hip fracture risk (P <0.0001), Garvan algorithm results for 10-year hip fracture risk (P<0.0001), and Pluskiewicz's algorithm (P = 0.0037) results were observed between the two groups.

	G1 (non-osteoporotic)	G2 (decreased LS BMD T-score)	P value
n	205	39	
Age (years)	59.75 ± 0.50	62.67 ± 1.18	0.0381
Menopausal age (years)	48.48 ± 0.36	48.67 ± 0.82	0.9289
Years after menopause (years)	11.27 ± 0.58	13.82 ± 1.33	0.0666
Height (m)	1.56 ± 0.05	1.53 ± 0.009	0.0294
Weight (kg)	52.66 ± 0.52	49.51 ± 1.19	0.0270
BMI (kg/m²)	21.67 ± 0.21	21.16 ± 0.49	0.2436
LS T-score	-1.03 ± 0.07	-2.92 ± 0.16	<0.0001
FN T-score	-0.99 ± 0.05	-1.64 ± 0.12	<0.0001
TH T-score	-1.19 ± 0.05	-1.58 ± 0.12	0.0115
FRAX® score for vertebral fracture risk	5.69 ± 0.32	6.89 ± 0.72	0.0560
FRAX® score for FN fracture risk	0.53 ± 0.12	0.93 ± 0.76	0.0002

Garvan algorithm for 5-year hip fracture risk	0.0004 ± 0.01	0.01 ± 0.01	<0.0001
Garvan algorithm for 10-year hip fracture risk	0.14 ± 1.82	0.03 ± 0.02	<0.0001
Pluskiewicz's algorithm (%)	5.85 ± 2.44	7.39 ± 3.48	0.0037

Table 2: Comparison of characteristics of G1 (n = 205) and G2 (n = 39)

BMI body mass index, LS lumbar spine, FN femoral neck, TH total hip, FRAX® Fracture Risk Assessment Tool, BMD bone mineral density

[a]Values are presented as mean ± standard deviation

[b]Age (P = 0.0381), height (*P* = 0.0294), weight (*P* = 0.0270), LS T-scores (*P* <0.0001), FN T-scores (*P* <0.0001), TH T-scores (*P* = 0.0115), FRAX® for FN fracture risk (*P* = 0.0002), Garvan algorithm results for 5-year hip fracture risk (*P* <0.0001), Garvan algorithm results for 10-year hip fracture risk (*P* <0.0001), and Pluskiewicz's algorithm (*P* = 0.0037) results were significantly different between the two groups.

A comparison of the characteristics of G1 (n = 205) and G3 (n = 23) is shown in Table 3. Significant differences in age (*P* = 0.0033), years after menopause (*P* = 0.0088), LS T-scores (*P* = 0.0003), FN BMD T-scores (*P* <0.0001), FRAX® scores for vertebral fracture risk (*P* <0.0001), FRAX® scores for FN fracture risk (*P* <0.0001), Garvan algorithm results for 5-year hip fracture risk (*P* <0.0001), Garvan algorithm results for 10-year hip fracture risk (*P* <0.0001), and Pluskiewicz's algorithm (*P* <0.0001) results were observed between the two groups.

	G1	G3 (decreased FN or TH BMD T-score)	*P* value
n	205	23	
Age (years)	59.74 ± 0.51	65.26 ± 1.53	0.0033
Menopausal age (years)	48.48 ± 0.36	48.83 ± 1.07	0.6133
Years after menopause (years)	11.27 ± 0.58	16.43 ± 1.73	0.0088
Height (m)	1.56 ± 0.0003	1.55 ± 0.01	0.6007
Weight (kg)	52.66 ± 0.52	51.33 ± 8.10	0.5553
BMI (kg/m²)	21.67 ± 0.21	21.46 ± 0.63	0.9947
LS T-score	-1.03 ± 0.07	-1.80 ± 0.21	0.0003
FN T-score	-0.99 ± 0.05	-2.32 ± 0.16	<0.0001
TH T-score	-1.19 ± 0.05	-2.67 ± 0.15	<0.0001
FRAX® for vertebral fracture risk	5.69 ± 0.32	10.78 ± 0.93	<0.0001
FRAX® for FN fracture risk	0.53 ± 0.12	2.67 ± 0.15	<0.0001
Garvan algorithm for 5-year hip fracture risk	0.0004 ± 0.01	0.03 ± 0.02	<0.0001
Garvan algorithm for 10-year hip fracture risk	0.14 ± 1.82	0.09 ± 0.15	<0.0001
Pluskiewicz's algorithm (%)	5.85 ± 2.44	11.13 ± 5.52	<0.0001

Table 3: Comparison of characteristics of G1 (n = 205) and G3 (n = 23)

BMI body mass index, LS lumbar spine, FN femoral neck, TH total hip, FRAX® Fracture Risk Assessment Tool, BMD bone mineral density

[a]Values are presented as mean±standard deviation

[b]Significant differences between the two groups with respect to age (*P* = 0.0033), years after menopause (*P* = 0.0088), LS T-scores (*P* = 0.0003), FN T-scores (*P* <0.0001), TH T-scores (*P* <0.0001), FRAX® for vertebral fracture risk (*P* <0.0001), FRAX® for FN fracture risk (*P* <0.0001), Garvan algorithm results for 5-year hip fracture risk (*P* <0.0001), Garvan algorithm results for 10-year hip fracture risk (*P* <0.0001), and Pluskiewicz's algorithm (*P* <0.0001) results.

	G2 (decreased LS BMD T-score)	G3 (decreased FN or TH BMD T-score)	*P* value
n	39	23	
Age (years)	62.31 ± 1.10	65.26 ± 1.53	0.1842
Menopausal age (years)	48.53 ± 4.03	48.83 ± 1.07	1.60003
Years after menopause (years)	13.78 ± 7.96	16.43 ± 1.73	0.2521
Height (m)	1.54 ± 0.06	1.55 ± 0.01	0.2932
Weight (kg)	49.04 ± 5.17	51.33 ± 8.10	0.4013
BMI (kg/m²)	20.77 ± 2.89	21.46 ± 0.63	0.5898
LS T-score	-2.89 ± 0.31	-1.80 ± 0.21	<0.0001
FN T-score	-1.72 ± 0.46	-2.32 ± 0.16	<0.0001
TH T-score	-1.58 ± 0.12	-2.67 ± 0.15	<0.0001
FRAX® for vertebral fracture risk	6.89 ± 0.72	10.78 ± 0.93	0.0051
FRAX® for FN fracture risk	0.87 ± 0.27	2.67 ± 0.15	0.0002

Garvan algorithm for 5-year hip fracture risk	0.01 ± 0.01	0.03 ± 0.02	<0.0001
Garvan algorithm for 10-year hip fracture risk	0.03 ± 0.02	0.09 ± 0.15	<0.0001
Pluskiewicz's algorithm (%)	7.39 ± 3.48	11.13 ± 5.52	0.0003

Table 4: Comparison of characteristics of G2 (n = 39) and G3 (n = 23) patients aged 50 to 79 years

BMI body mass index, LS lumbar spine, FN femoral neck, TH total hip, FRAX® Fracture Risk Assessment Tool, BMD bone mineral density

[a]Values are presented as mean±standard deviation

[b]Significant differences between the two groups with respect to LS T-scores (P <0.0001), FN T-scores (P <0.0001), TH T-scores (P <0.0001), FRAX® for vertebral fracture risk (P = 0.0051), FRAX® for FN fracture risk (P = 0.0002), Garvan algorithm results for 5-year hip fracture risk (P <0.0001), Garvan algorithm results for 10-year hip fracture risk (P <0.0001), and Pluskiewicz's algorithm (P = 0.0003) results.

Table 4 shows a comparison of complications of G2 and G3. There were significant differences in LS BMD T-scores (P <0.0001), FN T-scores (P <0.0001), TH BMD T-scores (P <0.0001), FRAX® for vertebral fracture risk, FRAX® for FN fracture risk, Garvan algorithm results for 5-year hip fracture risk (P <0.0001), Garvan algorithm results for 10-year hip fracture risk (P <0.0001), and Pluskiewicz's algorithm (P = 0.0003) results.

We also compared the complications, history of glucocorticoid use, history of steroid use, fracture history, family history of hip fracture of G1 and G2, G1 and G3, and G2 and G3 using Fisher's test. The family history of hip fracture was more prevalent in G2 than in G1 (P = 0.0244), and fracture history was more prevalent in G3 than in G1 (P = 0.0057). There were no significant differences between G2 and G3.

Discussion

Recent methods used to assess fracture risk (FRAX®, Garvan algorithm, Pluskiewicz's algorithm) have adopted only FN BMD to calculate the fracture risk. If a patient has significantly lower LS BMD than FN BMD, then the estimated risk could be different and inaccurate, thus leading to the fracture risk being overlooked. It is not uncommon to find discordance between the BMD T-scores obtained from the LS and FN because of the modest correlation in BMD between these two sites [10,22,23]. A study of osteoporotic fractures found that discordant spine and hip BMD values predicted different fracture patterns, and women with osteoporosis of only the spine were at increased risk for fracture compared with women without osteoporosis of the spine or hip [24]. Studies that have analyzed the relationship between discordance and fracture incidence have suggested that greater discordance is associated with a higher fracture risk [19, 20] and that discordance between LS and FN BMD T-scores can contribute to the fracture risk independently of the FRAX® probabilities, which incorporate only FN BMD [10].

To our knowledge, the present study is the first to examine age-specific discordance between LS BMD and FN BMD and to compare the characteristics of groups based on the FN BMD T-scores and LS BMD T-scores. Among the 50- to 79-year-old patients, we found that many exhibited LS and TH or FN BMD discordance and had lower LS BMD than TH BMD or FN BMD. In a recent study, several subjects exhibited LS BMD and FN BMD discordance, many of them had lower LS BMD than TH BMD or FN BMD, and subjects with vertebral fractures had more obvious increased estimated fracture risks when examining LS BMD instead of TH BMD or FN BMD [2].

We also compared the characteristics and complications among the groups. Height and body weight were lower in G2 group than in the non-osteoporotic group. The LS BMD T-scores and FN BMD T-scores were lower, and FRAX® scores for vertebral and FN fracture risk, Garvan algorithm results for 5-year hip fracture risk, Garvan algorithm results for 10-year hip fracture risk, and Pluskiewicz's algorithm results for 5-year hip fracture risk were higher for G2 than for the non-osteoporotic group. Additionally, G2 had a more prevalent family history of hip fracture compared with the non-osteoporotic group. More years after menopause had passed, the LS BMD T-scores and FN BMD T-scores were lower, and FRAX® scores for vertebral and FN fracture risk were higher, Garvan algorithm results for 5-year and 10-year hip fracture risk were higher, and Pluskiewicz's algorithm results for 5-year hip fracture were higher for G3 than for the non-osteoporotic group.

Several studies have estimated that lower LS BMD than FN BMD T-score may lead to an increased fracture risk, with this risk ranging between 10% and 30% depending on how the fracture risk was calculated [6,18,19]. In a recent analysis of a large referral cohort, there was an approximately 10% change in the fracture probability for each unit of T-score discordance, and the authors proposed that physicians may increase or decrease the FRAX® estimates for a major fracture by 10% for each rounded T-score difference between the LS and FN [9,20]. According to another study, women with significantly lower LS BMD T-scores than FN BMD T-scores (at least >0.6 SD) demonstrated consistently higher absolute fracture risks regardless of their FN BMD T-score [21].

There were some limitations to this study. First, this study had a very small sample size. Second, we could not study other risk factors such as nutrition, functional status, role of education, marital status, type of employment, or living environment [8]. However, the results of this study provided valuable information about spine–femur BMD T-score discordance. A higher prevalence rate of discordance between the two BMD T-score sites was shown, and many patients had lower LS BMD T-scores than TH BMD or FN BMD T-scores. Furthermore, limitations of FRAX® and other measurement methods for evaluating the fracture risk were shown. Based on the findings of this study, we suggest that physicians should more carefully assess women with low body weight or body mass index and a family history of hip fracture. For these patients, it is necessary to measure both the LS BMD and FN BMD T-scores for calculating the fracture risk. Moreover, it has been proven that bone metabolic markers as risk factors for fracture are independent of BMD. Therefore, we plan to determine whether these markers were increased in these patients. If these

bone metabolic markers were increased, then they can indicate an important auxiliary diagnosis of fracture risk.

Acknowledgments

We gratefully acknowledge the work of past and present members of our laboratory for helpful discussions and comments on the manuscript.

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