Is osteoporosis a risk factor for ankle fracture?: Comparison of bone mineral density between ankle fracture and control groups

Dong-Oh Lee, Joo-Hak Kim, Byung-Chan Yoo, Jeong-Hyun Yoo*

Department of Orthopedic Surgery, Myongji Hospital, Goyang, Korea

1. Introduction

Ankle fracture had been reported to be different from typical osteoporotic fracture, which involves hip, spine, and wrist fractures [1]. Traditional literature had reported the occurrence of ankle fractures in the elderly by the biomechanical factors is associated with more heavy weight or a trend for falls rather than osteoporotic bone quality [2,3]. However, recent studies suggested that ankle fractures in the elderly have the feature of osteoporotic fracture [4]. Additionally, several studies suggested that ankle fractures in postmenopausal women also have the features of osteoporotic fracture [5,6].

However, previous studies lacked consideration for body mass index (BMI), nevertheless BMI is reported to be related to bone mineral density (BMD) [7]. And it is important to investigate whether axial BMD is associated with the occurrence of ankle fracture as it can provide a valuable prospective for prevention of osteoporosis as well as its treatment; furthermore, it might be manifested that ankle fracture should be within the range of osteoporotic fracture like wrist fracture [4,8]. These give a rise to review of the relationship between ankle fracture and osteoporosis with perspective of BMI and BMD. Moreover, this concern has not been studied in Korea, to our best of knowledge.

Therefore, the aim of this study was to (1) compare axial BMD between patients with ankle fracture and normal population in Korea and (2) analyze the effect of BMI, which is considered as confounding factors. We hypothesized that axial BMD of ankle fracture patients would be significantly lower than that of the normal population.

2. Methods

This retrospective comparative study was initiated based on medical records of 433 patients who were treated in our hospital from 2006 to 2015. Inclusion criteria for the ankle fracture group were (1) patients aged above 50 years and (2) the presence of a medial malleolar fracture, lateral malleolar fracture, bimalleolar fracture,...
fracture, or trimalleolar fracture. Exclusion criteria included avulsion fracture, previous history of fracture or ankle surgery, and case with concomitant other fractures. As a result, 116 patients with ankle fracture (ankle fracture group) were included in our study. One hundred thirteen patients were selected as a control group who visited the orthopedic department for medical health checkup. This study was approved by the Institutional Review Board of Myongji Hospital and informed consent was waived because of retrospective design.

The level of trauma in patients with ankle fracture was classified as spontaneous fracture (level 0), minor trauma (a fall from standing height or less, level 1), and major trauma (a fall from greater than standing height or other high-energy injuries such as traffic accident, level 2) [3].

BMD at the lumbar spine and proximal femur in the noninjured leg (femoral neck, Ward triangle, and trochanteric area) was measured by dual-energy x-ray absorptiometry (DEXA) as g/cm² using Discovery W (Hologic Inc., Bedford, MA, USA) following standard protocols [9]. We routinely performed DEXA in patients who were admitted to the orthopedic department of the hospital. DEXA results were selected only when the test was done within 6 months after admission to hospital. Height and body weight of the patients were also routinely measured at the time of admission to the hospital. Height was measured to the nearest millimeter and weight was measured to the nearest 0.1 kg. Subsequently, BMI was calculated as body weight (kg)/[height (m)²].

The proportion of male to female was compared between the 2 groups using chi-square test. All variables were evaluated for normal distribution; as a result, 2-sample t-test was performed when comparing ankle fracture group with the control group.

The relationship between BMD and trauma level in ankle fracture group was also analyzed by 2-sample t-test because there was no level 0 injury in ankle fracture group.

Logistic regression analysis was done to identify the correlation among axial BMD variables and BMI of each group and other predictors from both the sets of variables. A P-value less than 0.05 indicated statistical significance. All analyses were performed using IBM SPSS Statistics ver. 22.0 (IBM Co., Armonk, NY, USA).

3. Results

The mean ages of ankle fracture and control groups were 68.1 ± 10.7 and 68.2 ± 10.8 years, respectively. Of all population, 46 patients were male and 183 were female patients. There was no difference in the proportion of male to female in both the groups (P = 0.870) (Table 1). Comparative analysis of demographic data between the 2 groups revealed that age of ankle fracture group also showed no significant difference compared to the control group (P = 0.968) (Table 1). In addition, higher BMI was noted in the ankle fracture group (P = 0.029) (Table 1). Axial BMD variables (region of lumbar, femur neck, and trochanter) with P = 0.634, P = 0.145, and P = 0.207, respectively showed no difference between the 2 groups. By logistic regression analysis, only BMI of 2 groups showed no significant effect on ankle fracture group (odds ratio, 1.1; 95% confidence interval, 1.01–1.20; P = 0.020). The energy level of trauma in ankle fracture group was related to only BMI and not axial BMDs (Table 2).

4. Discussion

Patients with ankle fracture tended to be younger and heavier than the normal group in this study. BMD of both two groups showed no significant difference even after controlling for BMI confounder. Accordingly, these results are largely in coincidence with previous literature.

| Table 1 | Comparison of demography between ankle fracture group and control groups. |
|---------|----------------------------------------------------------------------------|
| Variable | Ankle fracture (n = 116) | Control (n = 113) | P-value |
| Age, yr  | 68.1 ± 10.7               | 68.2 ± 10.8       | 0.968   |
| Sex, male:female | 24:92               | 22:91            | 0.870   |
| BMI, kg/m²   | 24.6 ± 3.3                | 23.6 ± 3.3       | 0.029*  |
| Male        | 24.1 ± 3.1                | 22.8 ± 1.8       |        |
| Female      | 24.7 ± 3.3                | 23.8 ± 3.5       |        |
| P-value     | 0.526                     | 0.156            |        |
| BMD         |                           |                 |        |
| L1–4       | 0.837 ± 0.157             | 0.847 ± 0.157   | 0.634   |
| Male        | 0.929 ± 0.147             | 0.939 ± 0.185   |        |
| Female      | 0.813 ± 0.151             | 0.824 ± 0.142   |        |
| P-value     | 0.001                     | 0.001            |        |
| Femur neck  | 0.631 ± 0.122             | 0.654 ± 0.116   | 0.145   |
| Male        | 0.708 ± 0.133             | 0.672 ± 0.101   |        |
| Female      | 0.610 ± 0.111             | 0.649 ± 0.120   |        |
| P-value     | 0.002                     | 0.348            |        |
| Trochanter  | 0.564 ± 0.112             | 0.583 ± 0.111   | 0.207   |
| Male        | 0.643 ± 0.120             | 0.623 ± 0.105   |        |
| Female      | 0.544 ± 0.100             | 0.573 ± 0.111   |        |
| P-value     | 0.001                     | 0.055            |        |

Values are presented as mean ± standard deviation or number. Ratio of sex was analyzed using chi-square test and others were analyzed by 2-sample t-test. BMI, body mass index; BMD, bone mineral density. *P < 0.05, statistically significant differences.

| Table 2 | Bone mineral density (BMD) according to trauma level in patients with ankle fracture. |
|---------|----------------------------------------------------------------------------------|
| Variable | Trauma level                                                                 |
|         | 0 (n = 0) | 1 (n = 95) | 2 (n = 18) |
| BMD     |           |           |           |
| L1–4    | N/A       | 0.837     | 0.835     | 0.919     | 0.637     |
| Femur neck | N/A       | 0.636     | 0.603     | 0.104     | 0.824     |
| Trochanter | N/A       | 0.565     | 0.568     | 0.063     | 0.547     |
| BMD, kg/m² | N/A       | 24.9      | 23.0      | 0.013*    | N/A       |
| P-value, by Mann-Whitney test, means significance of BMD difference according to trauma level. Adjusted P-value using partial correlation analysis (age, sex, and BMI controlled). | |

Ankle fracture is important because its hospitalization rate is known to be higher than wrist or vertebral fractures, which are classical osteoporotic fractures [10]. Several anatomic regions, which have been known as the source of osteoporotic fracture, are off the ground, so a motorist such as slip down or sitting down can have enough influence to break bones. In contrast, the ankle joint is always attached to the ground and hardly have chances to be impacted. And ankle may not have osteoporotic feature according to previous several literature and this study. So, the effects of heavy weight and daily activity on ankle fracture are more important than on any other fractures [11].

Previous literature have already analyzed the efficacy of estrogen in preventing the hip and distal radius fractures in postmenopausal women. The reports supported the solid evidence that estrogen offers protection against postmenopausal osteoporosis [12]. Although ankle fracture has not yet been determined as a typical osteoporotic fracture and there are still ongoing debates over this concern, recent studies suggested that ankle fracture have osteoporotic features. This issue is very important because it could provide crucial preventive and treatment policy for osteoporosis in cases where ankle fracture is one of the osteoporotic fractures.

Greenfield and Eastell [3] compared patients of ankle fracture with a normal population group, and found that overweight portion of a group with ankle fracture was significantly higher than
that of a normal group. The study revealed no differences in BMD between the 2 groups. However, numerous researches have investigated the relationship between BMI and BMD thereafter [7,13,14]. Thus, we studied this issue in the perspective of BMI and BMD because BMI could affect axial BMD as a confounding factor. Though our results were largely similar to the previous results, more studies such as the relationship between peripheral BMD and ankle fracture would be needed for identifying osteoporotic features of ankle fracture.

There are some limitations in our study. First, this study was performed with retrospective design and relatively small sample size, which could have masked the hidden relationship between BMI and BMD. Second, control group in this study could not be confirmed as true normal population because they might not be representative of Korean. Future studies are warranted to identify the osteoporotic features associated with ankle fracture.

5. Conclusions

Axial BMD could not be considered as a risk factor for ankle fracture, which is largely different from the typical osteoporotic fracture in Korean population. Only BMI affected the occurrence of ankle fracture in this study. Therefore, evaluation of osteoporosis for patients with ankle fracture should be considered separately.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

References

[1] Guggenbuhl P, Meadeb J, Chalès G. Osteoporotic fractures of the proximal humerus, pelvis, and ankle: epidemiology and diagnosis. Joint Bone Spine 2005;72:372–5.
[2] Hasselman CT, Vogt MT, Stone KL, Cauley JA, Conti SF. Foot and ankle fractures in elderly white women. Incidence and risk factors. J Bone Jt Surg Am 2003;85-A:820–4.
[3] Greenfield DM, Eastell R. Risk factors for ankle fracture. Osteoporos Int 2001;12:97–103.
[4] Lee KM, Chung CY, Kwon SS, Won SH, Lee SY, Chung MK, et al. Ankle fractures have features of an osteoporotic fracture. Osteoporos Int 2013;24:2819–25.
[5] Giannini S, Chiarello E, Persiani V, Luciani D, Cadossi M, Tedesco G. Ankle fractures in elderly patients. Aging Clin Exp Res 2013;25(Suppl 1):S77–S.
[6] Biver E, Durosier C, Chevalley T, Herrmann FR, Ferrari S, Rizzoli R. Prior ankle fractures in postmenopausal women are associated with low areal bone mineral density and bone microstructure alterations. Osteoporos Int 2015;26:2147–55.
[7] Wu SF, Du XJ. Body mass index may positively correlate with bone mineral density of lumbar vertebra and femoral neck in postmenopausal females. Med Sci Monit 2016;22:145–51.
[8] Briançon D, de Gaudenac JB, Forestier R. Management of osteoporosis in women with peripheral osteoporotic fractures after 50 years of age: a study of practices. Joint Bone Spine 2004;71:128–30.
[9] Lee SY, Kwon SS, Kim HS, Yoo JH, Kim J, Kim JY, et al. Reliability and validity of lower extremity computed tomography as a screening tool for osteoporosis. Osteoporos Int 2015;26:1387–94.
[10] Tarantino U, Capone A, Planta M, D’Arienzo M, Letizia Mauro G, Impagliazzo A, et al. The incidence of hip, forearm, humeral, ankle, and vertebral fragility fractures in Italy: results from a 3-year multicenter study. Arthritis Res Ther 2010;12:S226.
[11] Seeley DC, Kelsey J, Jergas M, Nevitt MC. Predictors of ankle and foot fractures in older women. The study of osteoporotic fractures research group. J Bone Miner Res 1996;11:1347–55.
[12] Hutchinson TA, Polansky SM, Feinstein AR. Post-menopausal osteostrogens protect against fractures of hip and distal radius. A case-control study. Lancet 1979;2:705–9.
[13] Kumar A, Sharma AK, Mittal S, Kumar G. The relationship between body mass index and bone mineral density in premenopausal and postmenopausal North Indian women. J Obstet Gynaecol India 2016;66:52–6.
[14] Lloyd JT, Alley DE, Hochberg MC, Waldstein SR, Harris TB, Kritz-Elof SB, et al. Changes in bone mineral density over time by body mass index in the health ABC study. Osteoporos Int 2016;27:2109–16.