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ORIGINAL ARTICLE

More radial shortening after low-energy Colles' fractures is associated with type 2 diabetes mellitus among postmenopausal women, irrespective of bone mineral density

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Abstract
Background Recent meta-analysis data reveal that patients with type 2 diabetes mellitus (DM) have a higher risk of fracture, despite higher bone mineral density (BMD), than patients without type 2 DM. The purpose of this study was to compare BMD and distal radial shortening after low-energy Colles' fractures among Japanese postmenopausal women aged ≥50 years with type 2 DM with those in women without it (non-DM).
Methods One-hundred and ten postmenopausal women aged ≥50 years with distal radius fractures resulting from a fall were enrolled in this study. Twelve patients had DM. BMD, type I collagen cross-linked N-telopeptide (NTX), undercarboxylated osteocalcin (ucOC), estimated glomerular filtration rate (eGFR), grip strength of the unfractured hand, unipedal standing time, and the degree of radial shortening were measured.
Results There were no significant differences in age and body height between the two groups. The DM group had significantly greater body weight and body mass index than the non-DM group. BMDs of the lumbar spine and proximal hip were significantly higher in the DM group than in the non-DM group. NTX, ucOC, grip strength, and the percentage of women with unipedal standing time <15 s did not differ between the two groups. Stepwise regression analysis identified DM and shorter unipedal standing time as significant factors associated with more radial shortening, and identified more radial shortening and lower eGFR as significant factors associated with DM.
Conclusions More radial shortening after low-energy Colles' fractures was significantly associated with type 2 DM among postmenopausal women aged ≥50 years, irrespective of BMD.

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Introduction

Type 2 diabetes mellitus (DM) occasionally accompanies postmenopausal osteoporosis. Type 2 DM is associated with a significant increase in forearm fractures (odds ratio 1.2, 95 % confidence interval (CI) 1.0–1.5) [1]. Recent meta-analysis data reveal that patients with type 2 DM are at higher risk of hip fracture despite higher bone mineral density (BMD) than patients without type 2 DM [2, 3]. Fracture risk to the hip, spine, or forearm is unchanged for patients with type 2 DM, even if insulin or oral antidiabetic drugs are used [1].

Bone fragility is attributable to BMD and bone quality [4]. Bone fragility associated with type 2 DM seems to depend on deteriorated bone quality rather than on reduced BMD. In other words, the mechanism behind bone fragility in type 2 DM seems to be poor bone quality. It is reported that type 2 DM causes enhanced accumulation of advanced glycation end-products in the collagen cross-linkage, which causes deterioration of bone quality [5].

The distal radius fracture is closely associated with osteoporosis [6]. Generally, low BMD is a strong predictor of osteoporotic distal radius fractures; comparison of women in the lowest quintile of BMD with women in the highest quintile showed that the incidence ratio was 4.1 for

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fractures of the distal radius [7]. For low-energy distal radius fractures resulting from falls among women aged more than 50 years, deformity of the fractured radius is significantly associated with lumbar BMD [8]. The amount of distal radial shortening after fractures is greater among women with osteoporotic lumbar BMD than among those without it [8].

For cases of low-energy distal radius fractures it still remains unclear whether type 2 DM affects the patients' characteristics, including BMD, bone metabolic markers, and extent of fracture displacement. Thus, in this study, we hypothesized that patients with type 2 DM have higher BMD but that more distal radial shortening is significantly associated with type 2 DM irrespective of BMD among elderly females with low-energy distal radius fractures because of a fall.

Materials and methods

Subjects

We prospectively and consecutively registered Japanese postmenopausal women aged ≥50 years with Colles-type distal radius fractures resulting from a fall. This is a prospective cohort study. We excluded participants with multiple fractures and systemic disorders of locomotive organs, for example symptomatic osteoarthritis, rheumatoid arthritis and other systemic collagen diseases, neuromuscular diseases, or postoperative status of the lower extremities. This exclusion was based on presurgical medical interviews.

We recruited the hospital patients from August 2007 to December 2010. Inclusion criteria were all of the following.

1. She has a distal radius fracture resulting from a low-energy fall at the height of the eyes. A fall was defined as unintentionally coming to rest on the ground or floor, against furniture, or against a wall from standing height or less. We excluded fractures due to high-energy injury events, for example traffic accidents and falls from approximately 10 cm above standing height.
2. She was admitted to either of the two hospitals.
3. She was surgically treated with volar locking plating without postoperative cast immobilization.

We invited a consecutive 110 patients who met the inclusion criteria. Nobody denied. Nobody had lumbar spine fractures. Examination was performed at our institution.

Type 2 DM was diagnosed by expert physicians in accordance with the diagnostic criteria of the Japan Diabetes Society. Twelve patients with type 2 DM were enrolled. Eight of these patients (66.7 %) were treated with oral hypoglycemic agents. No patients were treated with thiazolidinediones, including pioglitazone or rosiglitazone. Two patients were injected with insulin and the other 2 patients were treated with a dietary cure. There were no patients with type 1 DM in this study.

Hypertension (HT) was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or current treatment for HT. Dyslipidemia (DL) was defined as low-density lipoprotein cholesterol level ≥140 mg/dl, triglyceride concentrations ≥150 mg/dl, high-density lipoprotein cholesterol ≤40 mg/dl, or current treatment for DL. Mental diseases (MD), for example depression and anxiety neurosis, were diagnosed by expert psychiatrists and defined as current treatment for MD. Thirty-nine patients with HT, 19 patients with DL, and 22 patients with MD were enrolled.

At study entry, none of the subjects was institutionalized, and all lived independently. All subjects gave their written informed consent before examination, and all aspects of the study were approved by the institutional review board.

Physical measurements

We measured body height and weight in light clothing and without shoes. Body mass index (BMI) was calculated.

Bone mineral density

BMDs of the lumbar spine (L2–L4), left hip (total), and opposite unfractured distal radius (total) were measured by dual-energy X-ray absorptiometry (QDR-4500; Hologic, Bedford, MA, USA) at the follow-up visit. BMD of the lumbar spine was measured for all subjects, whereas BMDs of hip and radius were measured only in subjects who consented.

The respective percentages of the young adult mean (YAM) of lumbar spine, hip, and radius were calculated on the basis of the YAM value (aged 20–44 years) of the Japanese population [9]. In Japan, osteoporosis is defined as BMD below 70 % of YAM, on the basis of the diagnostic criteria for primary osteoporosis of the Japanese Society for Bone and Mineral Research [9].

Blood and urine examinations

Urinary type I collagen cross-linked N-telopeptide (NTX), a marker of bone resorption, was measured with trivalent peptides derived from N-telopeptide by enzyme-linked immunosorbent assay (Osteomark; Mochida Pharmaceutical, Tokyo, Japan). Serum undercarboxylated osteocalcin (ucOC) was measured by electrochemiluminescence