Analysis of Clinical Correlates of Lumbar Osteoporosis in Type 2 Diabetes Mellitus (Postprint)

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Abstract

Objective To analyze the correlation between lumbar spine bone mineral density (BMD) and age, gender, body weight, disease duration, fasting blood glucose, and other factors in patients with type 2 diabetes mellitus and osteoporosis. Methods Forty patients with type 2 diabetes mellitus complicated with osteoporosis and complete clinical data were enrolled as Group A, while 40 age- and gender-matched healthy physical examinees from the same period were identified as Group B using propensity score matching (PSM). BMD of the lumbar spine (L1-L4) and left femur was measured in both groups, and clinical parameters including gender, age, disease duration, body mass index (BMI), fasting blood glucose, serum calcium, serum phosphorus, urinary calcium, and urinary phosphorus were recorded for comparison. Results Lumbar spine BMD at L1-L4 in Group A was significantly lower than that in Group B ($P<0.05$). In patients with type 2 diabetes mellitus and osteoporosis, lumbar spine BMD was correlated with gender, negatively correlated with disease duration, and positively correlated with BMI, fasting blood glucose, urinary calcium, and urinary phosphorus, but showed no significant correlation with age, serum calcium, or serum phosphorus. Conclusion Decreased bone mineral density in patients with type 2 diabetes mellitus is associated with gender, BMI, prolonged disease duration, poor glycemic control, and other factors.

Full Text

Preamble

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Abstract

Objective: To analyze the clinical factors that contribute to lowered bone mineral density (BMD) of the lumbar vertebrae in type 2 diabetic patients. **Methods:** Forty type 2 diabetic patients with osteoporosis and 40 age- and gender-matched healthy individuals, selected using propensity score method, were examined for BMD of the L1 to L4 vertebrae and the left femur. Age, gender, course of the disease, body mass index (BMI), fasting blood glucose, serum calcium, serum phosphate, urinary calcium, and urinary phosphate were compared between the two groups. **Results:** BMD of the L1 to L4 vertebras was significantly lower in the diabetic group than in the healthy individuals ($P<0.05$). In the diabetic patients, BMD showed an obvious difference between male and female patients and was negatively correlated with the course of the disease but positively with BMI, fasting blood glucose, urinary calcium and urinary phosphate; BMD was not correlated with age, serum calcium or serum phosphate in these patients. **Conclusion:** Osteoporosis in type 2 diabetic patients is closely related with gender, BMI, course of the disease and poorly controlled glucose level.

Keywords: type 2 diabetes mellitus; osteoporosis; bone mineral density

Introduction

Osteoporosis (OP) is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and increased fracture risk. It represents a major public health threat due to its high cumulative fracture rate [1-2]. Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia resulting from defects in insulin secretion or action [3]. Epidemiological data indicate that compared with the general population, patients with diabetes exhibit significantly increased incidence of osteoporosis and higher risk of osteoporotic fractures [4-5].

Among diabetic complications, those affecting the cardiovascular, cerebrovascular, renal, ocular, cutaneous, and nervous systems are well recognized, yet diabetic osteoporosis has only recently gained attention in the medical community [6]. Clinical observations reveal that bone mass alterations in diabetic patients are closely associated with diabetes type. For type 1 diabetes, a consensus has emerged that it leads to reduced bone mass, whereas the impact of type 2 diabetes on bone mass remains inconclusive [9-10]. Although studies on risk factors for osteoporosis in type 2 diabetes have been reported [11-12], inconsistent conclusions often arise from varying inclusion criteria, and some data may be biased due to the lack of appropriately matched control groups.

Given these uncertainties regarding the relationship between type 2 diabetes and osteoporosis, we conducted this retrospective study with age-, gender-, and BMI-matched normal controls to investigate the correlation between BMD alterations and calcium-phosphorus metabolism as well as other clinical indicators in type 2 diabetic patients with osteoporosis. Our aim was to identify objective risk

factors for osteoporosis in this population and provide evidence for developing effective management strategies and clinical evaluation protocols for middle-aged and elderly diabetic patients.

Methods

1.1 Study Subjects

We retrospectively analyzed 40 patients with type 2 diabetes and osteoporosis (Group A) who were hospitalized in the Orthopedics and Endocrinology departments of Zhujiang Hospital. The group comprised 22 males and 18 females, aged 39-74 years (mean 57.14 years). All cases met the WHO diagnostic criteria for diabetes and osteoporosis, with strict adherence to exclusion criteria. Forty age- and gender-matched healthy individuals (Group B) were selected as controls using propensity score matching, including 25 males and 15 females aged 41-71 years (mean 56.98 years). All enrolled subjects had complete clinical information and detailed medical records.

1.2 Diagnostic Criteria

1.2.1 Diabetes Mellitus Type 2 diabetes was diagnosed according to WHO (1999) criteria: fasting blood glucose 7.0 mmol/L, or random blood glucose 11.1 mmol/L, or 2-hour plasma glucose 11.1 mmol/L during oral glucose tolerance test (OGTT).

1.2.2 Osteoporosis Osteoporosis was diagnosed based on WHO criteria using dual-energy X-ray absorptiometry (DXA): BMD within 1 standard deviation (SD) of the young adult mean was considered normal; BMD between 1 and 2.5 SD below the mean indicated osteopenia (-1<T-score<-2.5); and BMD 2.5 SD below the mean (T-score -2.5) was defined as osteoporosis.

1.3 Exclusion Criteria

The following conditions warranted exclusion: type 1 diabetes, gestational diabetes, or other specific types of diabetes; secondary osteoporosis due to hyperthyroidism, hyperparathyroidism, rheumatoid arthritis, renal disease, or severe gastrointestinal/hepatic/renal dysfunction; diabetic ketoacidosis, hyperosmolar hyperglycemic state, or other acute complications; history of prolonged bed rest; current use of glucocorticoids or other drugs affecting bone metabolism; and conditions interfering with normal implementation of nursing interventions including severe cardiovascular disease, senile dementia, severe cerebral hemorrhage or infarction, or illiteracy.

1.4 Measurements

1.4.1 General Data Collection Baseline information including gender, age, height, weight, body mass index (BMI=weight/height^2, kg/m^2), disease dura-

tion, medical history, and medication use were recorded.

1.4.2 Biochemical Indicators Fasting blood glucose (FBG), serum calcium (S-Ca), and serum phosphate (S-P) were measured using the BECKMAN CX9 automatic biochemical analyzer (Beckman Coulter, USA). Twenty-four-hour urinary calcium (U-Ca) and urinary phosphate (U-P) were also determined.

1.4.3 Bone Mineral Density Measurement BMD was measured in all enrolled subjects using the Norland XR-36 dual-energy X-ray bone densitometer (Norland, USA) with precision <1%. The L1-L4 lumbar vertebrae were measured separately, and mean lumbar BMD values were recorded and calculated using the instrument' s software.

1.5 Statistical Analysis

All data were processed using SPSS version 17.0. Measurement data were expressed as mean±standard deviation. Independent samples t-test was used for intergroup comparisons. Multiple correlation analysis was applied to explore relationships between BMD and age, diabetes duration, gender, BMI, blood glucose, S-Ca, and S-P. Pearson correlation analysis was employed for correlation assessments, with $P<0.05$ considered statistically significant.

Results

2.1 Comparison of Clinical Data Between Groups (Table 1)

No significant differences were observed between groups in age or gender composition ($P>0.05$), confirming comparability. BMI, S-Ca, and S-P levels also showed no significant differences. However, FBG, U-Ca, and U-P levels were significantly higher in Group A compared with Group B ($P<0.05$).

2.2 Comparison of BMD Between Groups (Table 2)

Lumbar spine BMD (L1-L4) was significantly lower in Group A than in Group B ($P<0.05$).

2.3 Correlation Analysis Between Osteoporosis and Clinical Indicators

Correlation analysis revealed that lumbar BMD in type 2 diabetic patients with osteoporosis was associated with gender and negatively correlated with disease duration, but positively correlated with BMI, fasting blood glucose, urinary calcium, and urinary phosphate. No significant correlations were observed with age, serum calcium, or serum phosphate.

Discussion

The relationship between diabetes and osteoporosis is complex [13]. Both in vivo and in vitro experiments have demonstrated comprehensive alterations in bone formation and microenvironment under diabetic conditions [14]. Studies indicate that the incidence of osteoporosis is significantly higher in type 2 diabetic patients [15-16]. Epidemiological research consistently shows an association between diabetes and increased fracture risk [7, 17], though fracture occurrence depends not only on BMD but also on bone quality, compositional changes, bone turnover, fall risk, and other factors [18].

In this study, we compared diabetic patients with osteoporosis to age-, gender-, and BMI-matched healthy controls. Our findings revealed that the severity of osteoporosis in diabetic patients was independent of age. Since the two groups were age-matched, our results further confirm that age-related osteoporosis was excluded as a confounding factor. The analysis demonstrated a significant relationship between osteoporosis severity and gender, with female patients showing markedly lower BMD values than male patients. Literature reports indicate that the prevalence of osteoporosis in type 2 diabetes is 38% in men and 65.3% in women [19-20], with female diabetic patients exhibiting significantly higher osteoporosis rates than males, likely due to greater declines in sex hormone levels [21].

Increased urinary glucose excretion in type 2 diabetes leads to corresponding increases in urinary calcium and phosphate loss, potentially causing calcium deficiency. Although blood calcium tends to decrease, feedback regulation reduces calcitonin secretion, enhancing osteoclast activity and bone resorption, ultimately maintaining normal serum calcium and phosphate levels [22]. Some studies suggest that increased osmotic urinary calcium and phosphate excretion in type 2 diabetes, leading to reduced secondary PTH and calcitonin secretion, represents an important mechanism of diabetic osteoporosis [13, 24]. Our data confirm that serum calcium and phosphate levels did not differ significantly from controls, and BMD showed no correlation with serum calcium or phosphate, but was significantly negatively correlated with urinary calcium and phosphate. The negative correlation between BMD and disease duration in our study further supports that persistent calcium and phosphate loss can exacerbate osteoporosis and reduce BMD.

Whether BMI is a primary determinant of BMD in type 2 diabetes remains controversial. Some studies report that BMD in type 2 diabetic patients is not reduced compared with normal individuals, and may even be increased, possibly due to higher BMI and initial hyperinsulinemia [20, 25]. However, this difference disappears after BMI correction, suggesting that higher BMD in diabetic patients may be partially attributable to elevated BMI. In our study, by matching normal controls without BMI differences, we found a significant positive correlation between BMD and BMI in the diabetic osteoporosis group, confirming that BMI is indeed a major determinant of BMD in type 2 diabetes.

In summary, this study compared diabetic osteoporosis patients with matched controls, examining the interplay among bone metabolism, endocrine function, and clinical disease course. Our findings demonstrate that BMD in type 2 diabetic osteoporosis is associated with multiple factors including gender, BMI, and calcium-phosphorus metabolism. These results provide valuable insights for clinical management and risk assessment of osteoporosis in middle-aged and elderly diabetic patients.

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Note: Figure translations are in progress. See original paper for figures.