BONE MINERAL DENSITY AT DIFFERENT LOCATIONS IN TYPE 2 DIABETES MELLITUS AND ANALYSIS OF FRACTURE SITES

XIAPANG RAO1, XIUJUAN SHI1, XIAOLIN CHI1, MEIYAN WAN2
1Department of Endocrinology, Chengyang People’s Hospital in Qingdao, Qingdao 266109, China - 2Department of Nephrology, Qingdao Municipal Hospital, Qingdao 266100, China

ABSTRACT

This study investigated changes in bone mineral density (BMD) at different locations in 125 patients with type 2 diabetes mellitus (T2DM) and 240 healthy controls between 2012 and 2015. BMD was assessed using dual-energy X-ray absorptiometry. BMD at L2 in men with T2DM was lower than in controls, and the difference was statistically significant (P<0.05). BMD in women with T2DM was lower at Ward’s triangle and the femoral neck than in controls, and the difference was statistically significant (P<0.05). The prevalence of osteoporosis was higher in women with T2DM (55.20%) and women without T2DM (29.16%) than in men with T2DM (28.80%) and men without T2DM (21.66%), and the difference was statistically significant (P<0.05). The prevalence of osteoporosis at L2 and L1-4 (5.40% and 16%) in men with T2DM was higher than that in men without T2DM (1.66% and 9.85%), and the difference was statistically significant (P<0.05). The prevalence of osteoporosis at Ward’s angle, the femoral neck, and the femur (20%, 12.80%, and 42.40%) in women with T2DM was higher than that in women without T2DM (3.33%, 5%, and 17.91%), and the difference was statistically significant (P<0.05). The preferred examination sites for early diagnosis of osteoporosis in men and women with T2DM are Ward’s triangle and L2, which are consistent with common osteoporotic fracture sites.

Keywords: Type 2 diabetes mellitus, bone mineral density, osteoporosis, fracture.

DOI: 10.19193/0393-6384_2018_5_190

Introduction

With the development of social economy and the acceleration of urbanization process, the increasing aging of population and popularity of obesity. Diabetes mellitus (DM) has become a major public health problem that affect the health of the residents. Because of absolute or relative deficiency of insulin, not only DM causes the metabolic disorder of body sugar, fat and protein, but also causes the metabolic disorders of calcium, phosphorus, magnesium and other elements, resulting in Osteopenia or osteoporosis of bone tissue1-3.

In recent years, studies have shown that the incidence of metabolic bone disease and the risk of fracture by OP in DM patients is significantly higher than that of ordinary people, the incidence of diabetic osteoporosis (DO) in type 1 diabetes (T1DM) is 48-72%4, and in T2DM is 20-60%5-6. At present, it can be determined that T1DM can reduce bone mineral density and OP5-6.

The relationship between T2DM and OP is still controversial6. Studies in this field show different results of low7 or high8 or normal9 bone mineral density.

Therefore, knowledge of fracture characteristics and BMD changes at different sites in patients with T2DM may be useful in prevention, thereby improving the quality of life in T2DM accompanied by OP.
Materials and methods

**Subjects**

DM group was 125 cases of hospitalized patients in the Department of endocrinology of the people’s Hospital of Chengyang District, Qingdao, in 2012 - 2015, which accords with the DM diagnostic criteria of WHO, including 45 male, 80 female (not menopause), they are age 30-55 years (44.69 + 11.72 years old); Group NDM was 240 cases of health checkup in the people's Hospital Health Center in Chengyang District, Qingdao, including 115 males and 125 females (no menopause) and the age was 32-56 years old (46.38 + 13.86 years old), Exclude DM by fasting and glycosylated hemoglobin detection; endocrine disorders such as pituitary, thyroid, parathyroid glands, adrenal glands and gonads were excluded; There was no primary heart, lung and kidney disease, and liver and kidney function were normal.

**Diagnostic criteria**

DM diagnosis was based on standard WHO (World Health Organization, 1999) criteria: fasting blood glucose ≥7.0 mmol/L or ≥11.1 mmol/L at 2 hours after glucose loading, or random blood glucose ≥11.1 mmol/L; asymptomatic individuals were retested on another day.

**Data collection and questionnaire design**

The contents include:
- The basic information of the subjects included name, sex, and birth year, height, weight, waist circumference (WC), hip circumference (HC), systolic pressure (SBP), diastolic pressure (DBP);
- Past health conditions included diabetes, history of cancer, past liver and kidney and other diseases, and fracture history, and so on the survey was conducted to complete the questionnaire by 2 doctors who had been formally trained.

**Investigation content of biochemical examination**

All subjects required fasting for 8-10 hours, and venous blood samples were taken. the function of liver and kidney, fasting blood glucose (FBG), glycated hemoglobin (HAI1C), total cholesterol (TC), triglyceride (TG), high density lipoprotein (HDL-c) and low density lipoprotein (LDL) were measured.

FPG was measured by glucose oxidase method, and Liver and kidney function and blood lipids were detected by automatic biochemical analyzer.

Medical personnel were sent to the community in batches and the subjects were taken to the hospital for BMD test with the US GE Lunar dual energy X-ray absorptiometry (DEXA). Bone mineral density (BMD) was measured in the anterior 1-4 vertebrae of the lumbar spine (L) and the proximal part of the left femur (femoral neck, greater trochanter, Word's triangle and total hip), T value is the standard for evaluating bone mineral density. The OP diagnostic standard for the World Health Organization (WHO): normal: T value≥-1SD; Osteopenia: -2.5SD < T value < -1SD; OP: T value ≤-2.5SD; Serious osteoporosis: T value ≤-2.5SD with fracture, DM diagnostic criteria refer to the diagnosis and classification standard of WHO.

**Equipment**

Biochemical testing was performed with a Hitachi 7180 automatic analyzer and a Siemens specific protein analyzer. BMD was assessed using a GE dual-energy X-ray absorptiometry instrument.

**Statistical analysis**

SPSS 16.0 software was used for analysis of measurement data, reported as mean±standard deviation; body mass index (BMI) = weight/height squared (kg/m2). Comparisons between two groups were performed with a t-test, and rates were compared using a χ2 test.

**Results**

**Comparison of general data**

There was no significant difference in age, height, HDL-c and TG between DM group and NDM group (P>0.05); However, the comparison between the two groups showed that the weight, BMI, FBG, WC and HAI1C of the DM group were higher than those of the DM group, and the difference was statistically significant (P<0.05) (Table 1).

**Comparison of bone mineral density**

The comparison of DM and NDM showed that the BMD of the L2 in Male with diabetes mellitus was lower than NDM, the difference was statistically significant (P<0.05). But there was no significant difference in the BMD of other vertebrae and L1-4.
between the two groups (P>0.05). The Wards triangle and femoral neck BMD of DM for female were lower than those of NDM, and the difference was statistically significant (P<0.05). However, there was no significant difference in the BMD of vertebral body, L1-4 and other femur (P>0.05) (Table 2).

Porosis was higher than that of female diabetes (28.80%) or non-diabetic (21.66%) and the difference was statistically significant (P<0.05). The prevalence rate of OP in female DM was (55.20%) higher than that of NDM (29.16%), the difference was statistically significant (P<0.05). L1, L3, L14 and other parts of the femoral OP prevalence rate was not statistically significant the difference between the two groups (P>0.05).

### Table 1: Comparison of the general data of the survey object.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
<th>BMI</th>
<th>WC</th>
<th>HAIc</th>
<th>FBG</th>
<th>Hdl-c</th>
<th>TG</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>125</td>
<td>57.69±13.72</td>
<td>169.43±5.10</td>
<td>71.44±9.49*</td>
<td>26.53±2.85*</td>
<td>86.7±9.8*</td>
<td>8.62±0.78*</td>
<td>9.53±0.96*</td>
<td>1.55±0.31</td>
<td>1.31±0.02</td>
</tr>
<tr>
<td>NDM</td>
<td>240</td>
<td>57.38±12.86</td>
<td>167.08±5.65</td>
<td>66.93±9.83</td>
<td>23.98±3.37</td>
<td>72.3±10.8</td>
<td>4.15±0.23</td>
<td>4.75±0.84</td>
<td>1.52±0.33</td>
<td>1.29±0.05</td>
</tr>
</tbody>
</table>

Note: Compared with NDM group, *P<0.05.

### Table 2: Comparison of bone mineral density in different parts of diabetes and non-diabetes.

<table>
<thead>
<tr>
<th>Group</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>DM</td>
<td>1.08±0.21</td>
<td>1.06±0.22</td>
<td>1.04±0.21*</td>
<td>1.19±0.26</td>
<td>1.24±0.24</td>
</tr>
<tr>
<td>NDM</td>
<td>1.07±0.22</td>
<td>1.07±0.21</td>
<td>1.21±0.25</td>
<td>1.26±0.21</td>
<td>1.25±0.20</td>
</tr>
</tbody>
</table>

### Table 3: Comparison of osteoporosis in patients with diabetes and non-diabetes.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Total</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N (M)</td>
<td>N (F)</td>
<td>L</td>
<td>M</td>
<td>F</td>
<td>R</td>
</tr>
<tr>
<td>DM</td>
<td>125</td>
<td>18</td>
<td>6</td>
<td>12</td>
<td>3</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>NDM</td>
<td>240</td>
<td>22</td>
<td>9</td>
<td>13</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Compared with NDM group, *P<0.05.

### Table 4: Comparison of fracture between diabetes and non-diabetes.

Note: Femur (F); radius (R); Tibia and fibula (T/F); other (O).
The prevalence rate of Wards triangle, femur neck and femur (20%, 12.80% and 42.40%) were higher than those of NDM (3.33%, 5% and 17.91%), and the difference was statistically significant (P<0.05). The OP prevalence rate of L1, L3, L14 was not statistically significant the difference between the two groups (P>0.05) (Table 3).

Comparison of fracture
The incidence of fracture in DM was 14.4% (18/125), including 6 male and 12 female. The incidence of fracture in NDM patients was 9.17% (22/240), including 9 men and 13 women. The fracture rate in DM was higher than that of in NDM, and the difference was statistically significant (X=8.632, P=0.001). The maximum number of fracture in male DM is L. The fracture site is consistent with male L2 and L1-4 that prone to OP; Secondly, the fracture site is the femur, radius and other parts, and The most common fracture site in female DM is L. The location of fracture is not consistent with female Wards triangles, femoral neck and femur, which is prone to OP, furthermore, the fracture site is the femur, radius and other parts (Table 4).

Discussion
DM is associated with OP at a microstructural level, with reduced mass per unit volume of bone in diabetic patients, decreased bone strength, and increased brittleness and risk of fractures due to systemic metabolic bone disease, and can lead to disability. Clinical studies have found that BMD in elderly men with T2DM was significantly decreased, with increased bone resorption and decreased bone formation, as well as macrovascular and microvascular complications. This study found that the prevalence of OP in men with DM (28.80%) was higher than that in men without DM. Moreover, the prevalence of OP at L2 and L1-4 (5.40% and 16%) was higher in patients with DM than in those without DM. Nicodemus et al. (16) reported a 1.7-fold increase in the rate of OP in women with T2DM compared with that in post-menopausal women without DM. This study found that the prevalence of OP in women with DM was 55.20% higher than that in women without DM, and that the prevalence of OP at Wards triangle, the femoral neck, and the femur (20%, 12.80%, and 42.40%) was higher than in those without DM (3.33%, 5%, respectively).

BMD is an important index of bone mineral metabolism. BMD measurement provides an effective and sensitive method for early diagnosis of OP. Because the proximal femur and lumbar cancellous bone ratio is relatively high, the bone metabolic rate is also high, and is prone to bone loss. Therefore, these locations should be used for BMD measurement. Sosa et al. found that the BMD at L2-4 in patients with DM was significantly lower than that in a control group; however, the BMD value in the proximal femur was not significantly different from that in a control group (17). This study found that BMD at L2 in men with DM was lower than in men without DM, but there were no differences at other locations. The BMD at Ward’s triangle and the femoral neck in women with DM was lower than that in women without DM, but there were no differences at other locations.

Studies have shown that the risk of hip fractures in patients with T2DM was greatly increased (18,19). This increase can be attributed to the risk of bone loss, with reduced strength. Kobayashi et al. (20) showed that BMD in the proximal femur and trochanter was significantly reduced in OP patients, easily leading to femoral neck and intertrochanteric fractures. This may be the main cause of femoral neck and intertrochanteric fractures in the elderly. Studies have found that the largest number of OP fractures in men with DM consistently occur at L1-4, compared with fractures at the femur and other locations. The largest number of OP fractures in women with DM consistently occur at Ward’s triangle, the femoral neck, and the femur, compared with fractures at other locations. This study is a cross-sectional study, and the sample content is relatively small, so the relationship between bone density and fracture is still limited, and the follow-up study is needed to further determine its causality.

Conclusion
T2DM is associated with OP. Women with DM should have BMD assessed at Ward’s triangle. However, men with DM should have BMD assessed at L2.
References


16) Nicodemus KK, Folsom AR; Iowa Women’s Health Study. Type 1 and type 2 diabetes and incident hip fractures in postmenopausal women. Diabetes Care 2001; 24: 1192-7.


Acknowledgments
We are grateful for the devotion of the following individuals in conducting this study: Changjiang Liu, Xiujuan Shi, Aiqin Gao. We are also grateful to Guang Wei, Lee, for statistical assistance; and Lin Liao, for critical reading of the manuscript. We also acknowledge Michael Biotechnology Co, Ltd, for providing Reagent supply during part of the study. We also thank patients of this study support.

Funding
The author was funded by research grants from Chengyang District, Qingdao, Shandong Province Science and Technology Bureau (2016-WJZD121).