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The True Factor Responsible for Femoral Neck Fracture

Sadamichi Ikeda and Zdenik A. Ralits

Abstract
Femoral neck fracture is called osteoporotic fracture. Thus it has long been presumed that the loss of bone mass must be responsible for this fracture. But when the accurate direct measurement of the bone mass of the cortical and trabecular bones was done, there was a slight correlation between the bone mass and the frequency of this fracture in the elderly. It became evident that other factors were the cause of the femoral neck fracture.

Histomorphometric study was done to find out the true factor causing the femoral neck fractures. The bone mass of femoral heads and iliac bones were significantly diminished in the fracture group below 60 years of age, but it was found to be no correlation between the loss of bone mass and the increase of the femoral neck fracture over 60. On the other hand, bone quality defect was far more frequent after 60 years of age in the fracture group. Thus the loss of bone mass was the important factor below 60 years old, but bone quality defect was the true factor over 60.


Key words: Bone mass, femoral neck fracture, bone quality defect, osteomalacia, histomorphometric measurement

Introduction

Osteoporosis becomes more common with age and femoral neck fracture frequently occurs in the elderly. Thus it has long been presumed that the loss of bone mass must be responsible for femoral neck fracture. However, when more accurate histomorphometric measurements were done in age matched control groups, it became more evident that other factors were the cause of the increase in the frequency of fractures. The purpose of this paper is to describe the true factor responsible for the increase in femoral neck fractures in the elderly.

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Materials and Methods

35 femoral heads and bone blocks of the iliac crest were obtained from females with intracapsular fracture of the hip at the same time. 25 unfractured samples were obtained from cadavers as a control group. (Table 1)

<table>
<thead>
<tr>
<th>years</th>
<th>Fracture group cases</th>
<th>Control group cases</th>
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<tbody>
<tr>
<td>( \sim 59 )</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>60 ( \sim 69 )</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>70 ( \sim 79 )</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>80 ( \sim 89 )</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>90 ( \sim )</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>25</td>
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Paraffin embedded sections were prepared from femoral heads and iliac bones which had been fixed in formalin and decalcified in formic acid. The sections were stained by the haematoxylin-eosin and Ralis tetrachrome method. The advantages of Ralis’s method compared with those using undecalcified sections are its simplicity, suitability for fixed and decalcified material in any unspecialised histological laboratory and the fact that osteoid and other bone components can be studied in sections of practically unlimited size and in undisturbed relationship to their surrounding soft tissues. Bone mass and osteoid area were calculated by the image analysis system. Bone quality defect which is confined to the normally mineralised parts of the bone and which is combined with osteopenia and sometimes with an excessive amount of osteoid was evaluated.

Results

The bone mass of iliac bones was significantly diminished in the fracture group below 60 year of age, but there was no difference between the fracture group and control group over 60. (Fig. 1)

Bone mass of femoral heads was calculated separately in the weight bearing area and nonweight bearing area. The bone mass in the weight bearing area was significantly more than that in the nonweight bearing area in all age groups.

The bone mass of the femoral heads of the control group was greater.
Fig. 1. Correlation of the bone mass in the iliac bones between the femoral neck fracture group (FNF) and the unfractured samples (Control).

The bone mass of iliac bones was significantly diminished in the fracture group below 60 years of age, but there was no difference over 60's.

that of the fracture group in those below 60 years old. But there was no difference over 70 years old. (Fig. 2)

Comparing iliac bones with femoral heads in the fracture group, bone mass of the iliac bones corresponded to that of the nonweight bearing area of the femoral heads. (Fig. 3)

Next, we looked at bone quality defect if this might be a factor. We divided this into three categories, mild, moderate and severe form. In the fracture group at least a mild and moderate form was seen in over 80% of iliac bones over all and its severe form was seen in 29% in the 60's: 67% in the 70's: 43% in the 80's: 53% in the 90's.

On the other hand in the control group at least a mild and moderate form was seen in 50% over all but the severe form was not seen from 50 to 70 years of age, and it was only seen in 25% in the 70's and 23% in the 80's. Bone quality defect was far more frequent and extensive after 60 years of age in the fracture group. (Fig. 4)

This same tendency was seen in the femoral heads in both areas. Thus, the loss of bone mass seems to be a significant factor up to about the age of 60 years, after which the increasing frequency of bone quality defect, corresponding closely to the frequency of femoral neck fractures, is the true factor.
Fig. 2. Relationship of the bone mass in the femoral heads between the femoral neck fracture group (FNF) and the unfractured samples (Control). The bone mass in the weight bearing area (W. B. A) was significantly more than that in the non-weight bearing area (non W. B. A) in all age groups. The bone mass of the control group was greater than that of the fracture group below 60 years old, but there was no difference over 70.

Fig. 3. Correlation of the bone mass in the fracture group between the femoral heads and the iliac bones. The bone mass of the iliac bones corresponded to that of the non-weight bearing area of the femoral heads.
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Fig. 4. Relationship of the degrees of the bone quality defect in the iliac bones between the fracture group (FNF) and the unfractured samples (Control).

The bone quality defect was far more frequent and severe after 60 years of age in the fracture group.

Next, we looked at the osteoid area to clear how about a role of osteomalacia causing the femoral neck fracture.

The osteoid area of heads and iliac bones was divided into 4 degrees: none: one plus: two plus and three plus. The two plus form was seen in heads in only two cases and the same result was obtained in iliac bones. (Fig. 5)
Fig. 5. Osteoid area in the femoral heads of the fracture group. The two plus form was seen in only two cases.

W. B. A : weight bearing area  non W. B. A : nonweight bearing area

Discussion

Osteoporosis is a dreadful problem of old age. The most common and obvious consequences are fractures. It has long been presumed that these patients must have some sort of osteoporosis causing the fracture.

Osteoporosis means the thinning of the bone. Its microscopical diagno-
sis is based on the diminished trabecular and cortical bone mass. A greater increase in the rate of loss of trabecular bone occurs in the perimenopausal period and it then slows down after 60 years old. For a long time, bone thinning seemed to be the most obvious finding in patients with osteoporotic fractures.

However, as with so many biological events in old age, for some time it was difficult to distinguish between causative and coincidental factors. Steven has realized that there is an incomplete correlation between the degree of osteoporosis and the tendency to incur fractures. There is a significant number of elderly patients with advanced osteoporosis who do not sustain fractures and not all cases with femoral neck fractures are osteoporotic. In several studies the bone mass in patients with femoral neck fractures was found to be normal, or higher than controls using the direct measurement of the trabecular bone mass.\(^{10,11}\)

In South Africa, Solomon, while comparing the bone mass of the black and white population, confirmed that in the fracture group there was no difference in bone mass. He postulated that some unknown factors or changes in the bone composition were the cause.\(^{12}\)

This evidence suggests that the dramatic increase in femoral neck fracture in the elderly is not a result of osteopenia, but is due to unknown factors. With the Ralis staining method, mineralization defects have been found in healing areas of aseptic bone necrosis and in bone from the paralysed limbs of children with spina bifida. The screening of cortical or trabecular bone samples from elderly patients with femoral neck fractures often shows areas in which the bone mineral is deficient or defective.\(^{13}\)

This condition, which is confined to the normally mineralized parts of the bone and which is often combined with osteopenia that seems significant but is contradicted several times in this paper and sometimes with an excessive amount of osteoid, is called bone quality defect. Bone quality defect stains purple or blue and the surrounding normally mineralized bone stains red. In many elderly people, there are widespread areas in the trabecular and cortical bone where the quality of the mineral and matrix is damaged at microscopical levels.\(^{11}\)

In the fracture group the trabecular bone mass was significantly lower before the age of 60. In individuals over 60, when the frequency of fractures is known to increase sharply, it did not significantly differ from the control group.

On the other hand, bone quality defect was far more frequent and extensive after 60 years of age in the fracture group, 80%, and the severe form was found in about 48% of them.
In the control group, the mild and moderate form was seen in 50% and the severe form in only 24%.

These findings indicate that diminished bone mass plays a significant role in those infrequent femoral neck fractures which occur in the younger age groups, but after the 60th year bone quality defect is the true factor responsible for their dramatic increase.

Osteomalacia was discussed by Chalmers\cite{14} and he reported six elderly patient with developed clinical and radiological osteomalacia who sustained subtrochanteric fractures. But in biopsies from 130 femoral neck fractures 12 per cent were found to have significant osteomalacia.\cite{15} There could be a slight correlation between the two.

In our study, the two plus form was seen in only two cases, so it seems that osteomalacia could play no more than a minor role in the etiology of the femoral neck fracture.

Conclusions

Below 60 years old, the loss of the bone mass was the main factor causing the femoral neck fracture. But over 60 years old, the true factor was the bone quality defect. Osteomalacia did not play a great role in causing the femoral neck fracture.

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(1988年12月27日受理)
大腿骨頸部骨折の発生に関与する真の因子について

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要 旨 大腿骨頸部骨折の発生には従来より骨量の減少が最も重要な因子とされて
いた。しかし、加齢に伴う骨量の減少と本骨折の発生頻度が相関しない事や、組織形態
学的な計測により骨折例で必ずしも骨量が低値を示さず、逆に多い例もあった。こ
の事実は、本骨折の発生には骨量の減少以外の因子が関与している事を示唆している。
そこで、骨折例と非骨折例の大腿骨頭と腸骨を摘出し各年代別に組織形態学的計測
をおこなった。その結果、60歳以下では、骨量の減少が最も重要な因子であったが、60
歳以上の骨折例では、骨梁中に一度正常に石灰化した部分から骨塩が抜け出た類骨が
大部分を占める傾域（bone quality defect）が広く、またその程度も強くもっていた。

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