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DEXA-MEASURED BONE DENSITY CHANGES OVER TIME AFTER INTERTROCHANTERIC HIP FRACTURES

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INDEXING WORDS

DEXA; bone density; intertrochanteric hip fracture; operation; compression hip screw

SYNOPSIS

The local bone density after an intertrochanteric hip fracture changes over time. In this study, bone density was measured in proximal femur and third lumbar vertebrae in patients treated for an intertrochanteric hip fracture at various periods. There were 60 patients (mean age 71.4 years) and 50 control patients (mean age 62.4 years). Bone density measurements were performed with Dual energy X-ray absorptiometry (DEXA). Bilateral measurements of the greater trochanter, lesser trochanter and femoral diaphysis as well as the third lumbar vertebrae were performed. Each area showed different course of change. The bone density of the greater trochanter and the lesser trochanter in the injured side increased after three months as compared with the control. After three years, the bone density of the greater trochanter decreased. The bone density of the femoral diaphysis and the third vertebrae gradually decreased over time.

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The authors suggest that bone density changes under the influence of callus formation, bone remodeling, decrease in daily activity, and use of ambulatory aids, etc.

INTRODUCTION

The local bone density after an intertrochanteric hip fracture will change over time. Factors which affect the bone mineral density (BMD) include the intertrochanteric hip fracture pattern, bone osteopenia, fracture callus formation, and bone healing and remodeling process. There are many reports about BMD after total hip or knee replacements, but no reports about BMD around hip fractures after operation. In this study, the authors measured BMD in multiple standardized sites of the proximal femur and third lumbar vertebrae in patients that had been treated for an intertrochanteric hip fracture. The measurements were compared with an age matched control group that had not experienced a hip fracture. The aim of this study is to determine the course of change of BMD after operation of hip fractures.

MATERIALS AND METHODS

There were 60 patients in this study. There were 20 men and 40 women. The mean age was 71.4 years. All patients have been treated due to an intertrochanteric hip fracture at Hyogo Prefectural Kaibara Hospital. Hereafter, these patients will be termed the "fracture group". Hemiplegic patients were excluded from this study. The 60 patients represented 101 Dual energy X-ray absorptiometry (DEXA) measurements over time. This was because the BMD of some patients were measured more than once as healing progressed over time.

All fractures were stabilized with compression hip screws, (hereafter referred to CHS). The CHS were manufactured by ACE MEDICAL COMPANY, California, USA, CHUGAI PHARMACEUTICAL CO. LTD., Tokyo, or ALPHATEC MFD.INC., California, USA. There were 50 control patients. The control patients were those who visited the out patient clinic for examination of BMD. In the control group there were 48 women and two men. The mean age of the control patients was 62.4 years.

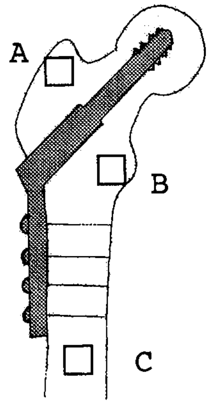

Fig.1.
Radiographic range of interest.

A:greater trochanter B:lesser trochanter
C:femoral diaphysis

BMD measurements were performed with a DEXA, (manufactured by Norland, XR-26). Bilateral BMD measurements of the greater trochanter, lesser trochanter and femoral diaphysis as well as the third lumbar vertebrae were performed on each patient. The radiographic range of interest (ROI) of the femur was established at $0.81cm^2$, (Fig. 1).

In the fracture group the BMD of the greater trochanter, lesser trochanter, femoral diaphysis, and the third lumbar vertebrae was measured in both the fractured and normal hips. The ratio of the femoral DEXA measurements between the injured and uninjured sides were calculated. This ratio was termed the bone density ratio of the femur. In the control group DEXA measurements were obtained in both hips. The bone density ratio of the femur in the control patients was determined with this data. The vertebral bone density ratio was calculated by comparing the vertebral DEXA measurements in the operated group and the control group with standardized mean values by age,[21] (Table).

The fracture group of patients was divided into five, time dependent sub-groups. Group one had 31 cases that were one month or less after surgery. Group two had 18 cases that were between one and three months after surgery. Group three had 26 cases that were between three months and one year after surgery. Group four had 14 cases that were between one and three years from surgery. Group five had 12 cases that were more than three years from surgery. The DEXA measurements from all five groups were compared with the control group DEXA measurements to determine BMD change with the passage of time.

Table. Bone Density Ratios.

Operated group :	**BMD of affected side**	/	**BMD of normal side**
Control group :	**BMD of right side**	/	**BMD of left side**
Lumbar vertebrae :	**BMD of the patient**	/	**standardized normal mean value by age**

Additionally, the authors investigated in the fracture group whether changes in fracture pattern with overlap of fracture fragments influenced the DEXA measurements. The authors divided the 31 cases of sub-group one, of the fracture group, into two additional sets. Set (A) contained 19 cases and had radiographic evidence of overlap of the fracture fragments. Set (B) contained 12 cases and did not show radiographic evidence of overlap of the fracture fragments. The femoral bone density ratio of the cases in set (A) and set (B) were compared with the control group. These data were examined with Mann-Whitney's U-test.

RESULTS

1. *Bone density ratio of the greater trochanter,* (Fig. 2).

The average bone density ratio of the greater trochanter for the control group was 1.00 ±0.17. The average greater trochanteric bone density ratios of the operated sub-group,1-5 were 1.37 ±0.37, 1.70 ±0.58, 1.45 ±0.53, 1.59 ±0.80 and 0.95 ±0.40, respectively.

The bone density ratios of operated sub-group 1-4 were significantly higher when they are compared to the bone density ratio of the control group ($p<0.01$). In contrast, the bone density ratio of the 12 cases in sub-group five did not show a significant difference when compared to the control group.

2. *Bone density ratio of the lesser trochanter,* (Fig.3).

The average bone density ratio of the lesser trochanter in the control group was 1.00 ±0.15. The average lesser trochanteric bone density ratios of the operated sub-group,1-5 indicated 1.24 ±0.45, 1.61 ±0.49, 1.56 ±0.49, 1.43 ±0.60 and 1.40 ±0.57, respectively.

The ratio in each sub-group was significantly higher than in the control group. Additionally, there was a significant difference between the bone density ratio of the operated sub-group one with operative sub-group two, ($p<0.05$).

3. *Bone density ratio of the femoral diaphysis,* (Fig. 4).

The average bone density ratio of the femoral diaphysis in the control group was 1.02 ±0.09. The average femoral diaphysis bone density ratios were 1.07 ±0.20, 1.00 ±0.14, 0.97 ±0.14, 0.94 ±0.18 and 0.78 ±0.20 of the operated five sub-groups,1-5 respectively.

The femoral diaphyseal bone density ratio of sub-group five was significantly lower than that of the control group ($p<0.01$).

4. *Bone density ratio of the third lumbar vertebrae,* (Fig.5).

The average bone density ratio of the lumbar vertebrae in the control group was 0.90 ±0.24. The average lumbar vertebrae bone density ratios were 0.81 ±0.31, 0.85 ±0.23, 0.91 ±0.29, 0.73 ±0.28 and 0.51 ±0.22 of the operated five sub-groups,1-5 respectively.

Similar to the findings with the femoral diaphysis the lumbar vertebral bone density ratio of operated sub-group five was significantly lower than that of the control group ($p<0.01$).

5. *Changes of bone density ratio with overlap of fracture fragments.*

The bone density ratio of the greater trochanter in patients with radiographic evidence of fracture fragment overlap was 1.50 ±0.37. The bone density ratio of the greater trochanter in patients without fracture fragment overlap was 1.10 ±0.23. The bone density ratio was significantly higher in the overlap cases than those in the cases without overlap($p<0.01$).

The bone density ratio of the lesser trochanter in fracture overlapped fragment cases was 1.31 ±0.50 and 1.15 ±0.40 was observed in the bone density ratio of the lesser trochanter without overlapping fragment. The bone density ratio was higher in the overlapped cases than in the cases without overlap. However, the difference in the bone density ratio between these two groups was not significant.

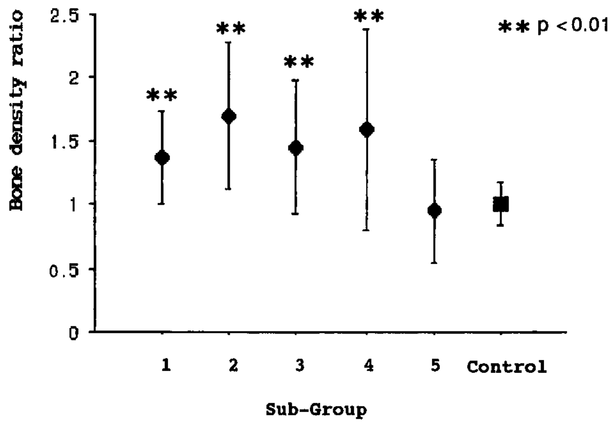

Fig.2. Bone density ratio of the greater trochanter.

Sub-group 1:one month or less, sub-group 2:between one month to three months, sub-group 3:between three months to one year, sub-group 4:between one year to three years, sub-group 5:more than three years after surgery.

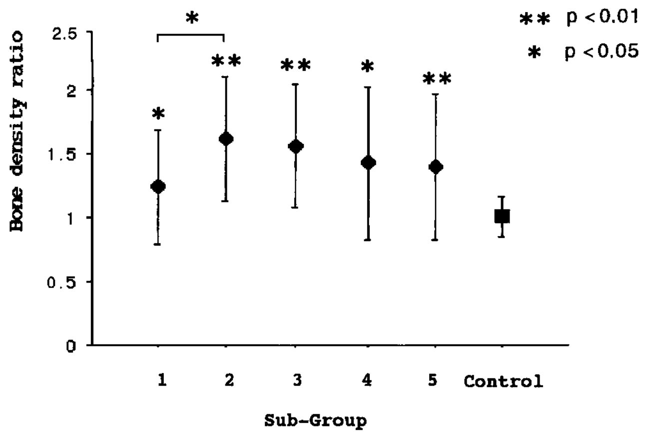

Fig.3. Bone density ratio of the lesser trochanter.

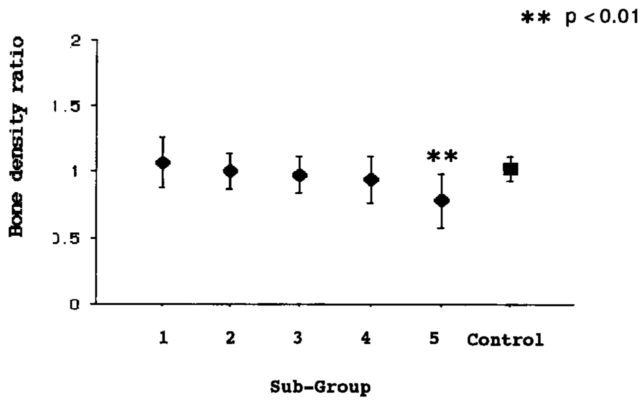

Fig.4. Bone density ratio of the femoral diaphysis.

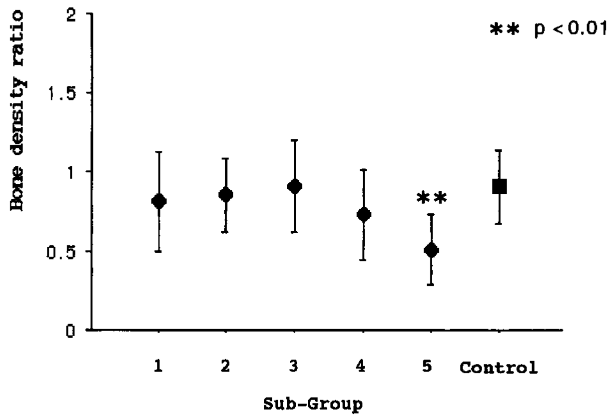

Fig.5. Bone density ratio of the lumbar vertebrae.

DISCUSSION

DEXA bone density measurements are widely performed and accepted as easy to obtain, reliable and reproducible. The literature contains many DEXA studies that have examined the local change in bone density after a fracture,[2,11,14] total hip or knee replacement.[6,10,12,13,15] Studies have been published that have suggested that femoral DEXA measurements could be correlated with femoral strength.[17] Therefore, serial DEXA measurements of a fractured hip over time could reflect changes in bone strength as the hip healed.

Bone metabolism at a fracture site is accelerated and this may have a direct effect on BMD at the fracture site. Frost[9] described systemic factors that included vitamin D, hormones, and traumatic stress as factors that influenced BMD measurements. Other authors have also described the pre-injury bone mass, systemic illness, changes in the patient's activities of daily living, and changes in weight as additional systemic factors that effect BMD measurements.[5]

Local factors have also been described that can effect BMD measurements. Local factors may include the fracture pattern with overlapping fracture fragment or a bone defect. Local soft-tissue ossification, callus formation, bone resorption, disuse osteopenia, deformity induced changes in the weight-bearing axis, and biomechanical effect of stabilization devices are some local factors that can influence BMD measurements.[1]

The local and systemic factors that influence BMD are very complicated. Additionally, the local and systemic factors that effect BMD will not have an identical influence on all regions of a bone. The authors recognized that each region of the femur is unique and factors that influenced BMD measurements would have a different effect on different regions of the femur and lumbar vertebrae. Therefore, the authors measured the bone density in the greater trochanter, lesser trochanter, femoral diaphysis and lumbar vertebrae. The measured BMD of the three regions of the femur and lumbar vertebrae were different and had distinctive changes over time as shown in Figures 2 through 5.

Bone density ratio in the greater and lesser trochanters

The bone density ratio in the greater trochanter was increased until three months after surgery. The increased greater trochanteric bone density ratio was generally sustained during the three year period after surgery and was significantly higher than that of control cases. After three years the greater trochanteric bone density ratio subsided and there was no difference between the operated cases and the control cases.

The bone density ratio in the lesser trochanter was significantly increased until three months and sustained until three years after surgery. After three years the lesser trochanteric bone density ratio in the operated cases was still significantly higher than the bone density ratio of the control group.

The authors have postulated why there is an observed different change in the bone density ratio of the greater and lesser trochanters after three years. Frequently, intertrochanteric fractures involve both the greater and lesser trochanteric regions of the proximal femur. During the first three months after fracture these regions will be influenced by callus formation and bone resorption. In many cases radiographic evidence of callus formation was observed involving both the greater and lesser trochanteric regions of the proximal femur within three months after fracture. The presence of fracture callus was interpreted as evidence of clinical fracture healing. The increased bone density measurements of the greater and lesser trochanters were also suggestive of strengthening of the bone and fracture healing.

Usami[19] have reported that the fracture site bone density will gradually increase and return to the pre-injury density within three to six months after the injury.

The authors observed a different pattern of bone density ratio for the greater and lesser trochanters three years after surgery. Arai and others[3] measured stress in a model in which the femoral head was physiologically loaded. They reported that the greater trochanter was subjected to a small amount of tension when the femoral head was loaded. However, they also measured a substantial compressive stress that acted directly on the lesser trochanter.

The authors have not identified the reasons for the different BMD measurements after three years between the greater and lesser trochanters. However, it may be a function of the fracture callus remodeling under the influence of physiological stress loading on these regions. It appears that remodeling of the greater trochanter occurs approximately three years after surgery and remodeling in the lesser trochanter requires a longer period. Additional research will be necessary to obtain a more precise definition of the factors that influence the observed measurements over time.

Bone density ratio in the femoral diaphysis and lumbar vertebrae

Ulivieri[18] studied bone density in patients with fractured legs. Uliveri measured the BMD at the distal region of the fracture site with the passage of time and reported that regardless of when loading of the fracture was initiated the BMD continued to decrease until 120 days after the injury.

Van Der Wiel[20] reported that in patients with tibial fractures femoral BMD of the ipsilateral side was diminished even after loading was started, and the BMD did not recover even one year after the injury.

In this study the BMD in the femoral diaphysis gradually decreased during the three year period after injury. Three years after the fracture the femoral diaphyseal bone density ratio remained significantly suppressed when compared with the control measurements. It is reported that factors which may influence the BMD include the local tissue injury with fracture, the trauma of surgical management of the fracture, alteration in the loading of the femur both from intrinsic aspects of the bone and extrinsic ambulatory aids.[7,8,9,16] Baxter[4] reported that crutches and canes decrease the load to legs. Therefore ambulatory aids could affect BMD changes.

The bone density ratio in the lumbar vertebrae was calculated by comparing the measured bone density with published average values by age. The change in the vertebral bone density ratio over time was similar to the change in the bone density ratio of femoral diaphysis over time. The authors suggest that the relative decrease in activities of daily living and the use of ambulatory aids after the fracture mainly contribute to the measured diminished post-operative BMD.

Bone fracture fragment overlap

The bone density ratios of both the greater and lesser trochanters were greater than the control cases one month after surgery. This increase was observed in a period that was still too early for significant fracture callus formation. Therefore, the most reasonable explanation of the higher BMD in this period was overlap of the fracture fragments.

CONCLUSIONS

1. The bone density ratio of the greater and lesser trochanter increased after three months after surgery and sustained. This fact supports the clinical judgement of fracture union by X-ray pictures.
2. The bone density ratio of the greater trochanter decreased

after three years, whereas that of the lesser trochanter sustained. It appears that the different pattern of physiological stress loading contributed to the difference of remodeling of these regions.

3. The bone density ratio of the femoral diaphysis and the lumbar vertebrae gradually decreased over time.

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