Original Article :

Are High Risk Patients of Femoral Neck Fractures Predictable from the Severity of Osteoporosis?

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Proximal femur fractures (PFFs) are a major cause of disability in the elderly. Some reports say that osteoporosis is a factor contributing to PFFs and values of bone mineral density (BMD) can be used to predict PFFs. In this study we investigated the possibility of using BMD monitoring to predict the risk of PFFs.

This study compares a PFF group with a nonfracture control group. The selection criteria for both groups were female patients, age 60 and over, on whom dual energy x-ray absorptiometry (DXA) was performed. The PFF group was composed of 52 patients who were treated between Feb. 1997 and Nov. 1998 and DXA was performed within two weeks postoperatively. The nonfracture control group was made up of 27 patients who were treated for total knee replacement between April 1998 and Dec. 1998 and DXA was performed within two weeks preoperatively.

Histograms were made using BMD data from lumbar and proximal femor measuring sites. The histograms were used to produce receiver-operating characteristic (ROC) curves. After analysing the histograms and ROC curves, two ranges of interest in each DXA report, neck and Wards were selected as the best sites to use when comparing the PFF and control groups.

The two groups were compared to determine cut-off levels for PFFs. For the assessment of fracture risk of the patients with osteoporosis, we would like to propose for neck, 0.600 g/cm² BMD in which sensitivity is 76% and specificity is 80%. And for Wards, 0.400 g/cm² BMD in which sensitivity is 71% and specificity is 81%.

①Proximal femoral fracture ②Osteoporosis ③Bone mineral density

Introduction

It is a well-known, and regrettable, fact that elderly patients with hip fractures often end up in a bed-ridden state. It is common knowledge that hip fracture patients suffer

from osteoporosis. Some reports state that the risk of hip fractures can be predicted from the severity of osteoporosis which can be estimated by measuring bone mineral density (BMD). In this study we tried to prove the possibility of the prediction of hip fracture by measuring BMD.

Subjects and methodology

From February 1997 to November 1998,

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we treated 74 female patients, aged 60 years and over for osteoporosis-related hip fractures in our department. Of these, we chose 52 cases (52 limbs) as a fracture group and measured BMD within two weeks postoperatively. This group consisted of 20 neck, or medial type, and 32 intertrochanteric, or lateral type, of proximal femoral fractures and their BMD measurements were taken on the non-fracture side, 26 on the right, and 26 on the left. The average age of this group was 79.9 years and the age range was 60–92 years. As a control group, we chose 27 female patients. They were free of hip fractures, but underwent total knee replacement in our department from April 1998 to December 1998. Their BMD measurements were taken within two weeks preoperatively with their proximal femur sites being measured on the non-operative site, 10 on the right and 17 on the left. The average age was 73.3 years and the age range was 63–84 years (Table 1). The analy-

sis by Student-t test showed that there were no significant difference in age between the two groups.

Dual energy x-ray absorptiometry (Expert 2000, lunar company, USA) was used to measure BMDs, which read both lumbar and proximal femur bone densities. In the lumbar spine, the bone density was measured for each lumbar vertebra from the second to the fourth separately and synthesized for combined area if necessary (Fig. 1). In the proximal femur the bone density was measured by dividing the adjacent area into four parts, which are named neck, Wards, trochanter and shaft in a Expert 2000 BMD report. The value for BMD in Wards is the computer calculated smallest density figure about the certain square area in the neck, which is not geographically equivalent to the Ward's triangle of the neck (Fig. 2).

In the process of analysis, we selected the three most reliable sites, 2nd–4th Lumbar,

Table 1 Characteristics of the patients in the fracture and nonfracture groups

	Fracture group	Nonfracture group
No. of cases	52 females	27 female
Age (years : mean, range)	79.7 (60~92)	73.3 (63~84)

Fig. 1 BMD measurement sites for lumbar spine in DXA

Fig. 2 BMD measurement sites for proximal femur in DXA

neck, and Wards out of 9 lumbar and proximal femur measuring sites by visually comparing histograms obtained from each. We then determined the cut-off values for femoral fractures from the receiver-operating characteristic, or ROC curves obtained from the above mentioned three sites.

Results

In the fracture group, the mean densities of the second lumbar vertebra (L2), the third lumbar vertebra (L3), the fourth lumbar vertebra (L4) and from the second to the fourth lumbar vertebrae (L2-4) were 0.716 g/cm², 0.766 g/cm², 0.843 g/cm² and 0.775 g/cm², respectively. In the nonfracture group, the mean densities of L2, L3, L4 and L2-4 were 0.835 g/cm², 0.931 g/cm², 0.988 g/cm² and 0.917 g/cm², respectively.

In the fracture group, the mean densities

of the neck, Wards, trochanter, shaft and total region were 0.535 g/cm², 0.535 g/cm², 0.535 g/cm², 0.535 g/cm² and 0.535 g/cm² respectively.

In the nonfracture group, the mean densities of neck, Wards, trochanter, shaft and total region were 0.640 g/cm², 0.473 g/cm², 0.552 g/cm², 0.866 g/cm², 0.713 g/cm², respectively (Table 2).

In order to evaluate the distribution trait of each site in the fracture group and in the nonfracture group, the data were shown in the form of histograms. Among the four sites in the fracture group, the histogram of L2-4 was most closely distributed in accordance with the normal curve (Fig. 3). In the nonfracture group, of the five proximal femoral measurement sites, only neck and Wards densities were distributed in nearly normal curve (Fig. 4).

Table 2 Bone Mineral Densitise in the Lumbar vertebrae and the Proximal femur

	Mean BMD g/cm ² (range g/cm ²)	Mean BMD g/cm ² (range g/cm ²)
Lumbar vertebrae		
L 2	0.716 (0.354~1.217)	0.835 (0.537~1.318)
L 3	0.766 (0.353~1.272)	0.931 (0.554~1.392)
L 4	0.843 (0.388~1.373)	0.988 (0.644~1.369)
L 2-4	0.775 (0.372~1.251)	0.917 (0.614~1.352)
Proximal femur		
neck	0.535 (0.292~0.771)	0.640 (0.104~0.799)
Wards	0.349 (0.104~0.600)	0.473 (0.231~0.677)
trochanter	0.422 (0.171~0.776)	0.552 (0.359~0.702)
shaft	0.684 (0.392~1.089)	0.866 (0.523~1.122)
total proximal femur	0.561 (0.317~0.888)	0.713 (0.447~0.890)

Fig. 3 Histograms of the BMD data for the 2nd lumbar, the 3rd lumbar, the 4th lumbar and the 2nd–4th lumbar vertebrae in the fracture group

Fig. 4 Histograms of the BMD data for each site of the proximal femur in the fracture group

Fig. 5 Histograms of the BMD data for the 2nd–4th lumbar vertebrae, neck and Ward's BMD in the nonfracture group

Therefore, we decided to use data from three sites—L2–4, neck and Wards—for analysis because of their close distribution patterns to the normal curve.

In the nonfracture group, the histogram of Wards density was distributed in a normal curve, however, L2–4 and neck distributions were far from normal curves, probably because of the small number of samples, 27, in this group (Fig. 5).

In order to determine cut-off values for hip fractures, we have first drawn ROC curves of three items—L2–4, neck and Wards. As we expected from the poor normal distribution of L2–4 density in the nonfracture group, the ROC curve of L2–4 did not appear to be acceptable in the graph (Fig. 6). Therefore we tried to set cut-off levels on two items, neck and Wards curves, using the percentile curves of neck and Wards. In the process of assessment of appropriate values for cut-off levels at each site, we determined to put a cut-off level for neck BMD at 0.600 g/cm² where the sensitivity is 76% and specificity 80%, and for Wards BMD at 0.400 g/cm² where the sensitivity is 71% and specificity 81% (Fig. 7).

Discussion

It has been suggested that the occurrence of hip fractures is attributable to decreased

Fig. 6 ROC curves of the BMD in the neck, Ward's and the 2nd–4th lumbar vertebrae derived from the fracture and nonfracture groups

impedance in the skeletal system and increased risk of falling¹⁾. In daily life, falling seems the most important factor for hip fractures, however, Fujii et al. reported in their study using cadaveric femur bones that the force required to cause fracture in the proximal femur decreased dramatically as the region became more osteoporotic, citing that the grade II or III osteoporotic states in Singh index²⁾ were 3 or 4 times more susceptible to fracture than the state of Grade IV³⁾. This leads us to think that the measurement of BMD is essential for precise assessment of the risk of fracture in the osteoporotic age

Fig. 7 Percentile graphs of the BMD of the fracture and nonfracture groups for the neck and Ward's at the proximal femur to figure out sensitivity and specificity for neck fracture risk

group.

In our daily medical practice, the lumbar spine is the main target for measurement of bone mineral density because of its accuracy in measurement by dual energy x-ray absorptiometry. Since the lumbar spine consists in most part of cancellous bone, it can more easily reflect bone loss in the menopausal phase. But measurement of spine density in elderly population is not always accurate because of spondylosis of the lumbar vertebrae or occurrence of calcification of the abdominal aorta⁴⁾. On the other hand, scanning on the proximal femur can avoid such inaccuracies in measurement, because of no or less severe change with aging.

Cummings et al. concluded that from measurements of bone density in the proximal femur predict fractures can be predicted better than from measurements taken at the other skeletal sites⁵⁾. Our results confirm theirs. Among the several sites in the proximal femur, we concluded that monitoring of BMD in either neck or Ward's is the best site to refer to in order to predict hip fractures.

The cut-off levels that we determined in this study, on the basis of percentile graphs

and ROC curves by setting sensitivity in the seventies and specificity in the eighties, which we think the reasonable values for clinical analysis, are 0.600 g/cm² for neck and 0.400 g/cm² for Ward's. These cut-off levels coincide well with the value at the 90th percentile for hip fractures in other reports published in Japan.

As the number of elderly people increases in Japan, the number of osteoporotic patients goes up as well. As a result, more people suffer from osteoporosis-related fractures such as spine, forearm, shoulder or hip fractures. Hip fracture is of course the most crucial one for the elderly because of restriction on their daily activities and social life, the high cost of treatment including surgical operation, and occasional fatalities. It is important to assess major risk factors for hip fractures for clinical practice.

We would like to propose the above mentioned cut-off levels neck and Ward's bone densities in a DXA study as the reference values for assessing the risk for fractures in patients who have osteoporosis. For patients whose bone densities are below the cut-off levels, we will be able to warn them of the

presence of the high risk of hip fractures beforehand, giving them suggestions about prevention from falling or providing indoor conditions free from falling.

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大腿骨頸部骨折における骨粗鬆症の関与について —— 骨折危険群は予測できるか？ ——

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〔目的〕 大腿骨頸部骨折（以下頸部骨折）は老人の寝たきりの原因となりやすい。頸部骨折には骨粗鬆症が関与していると言われており、骨折のリスクを予測するのに骨密度（以下 BMD）測定の意義が報告されている。今回われわれは大腿骨頸部骨折の危険群を BMD で予測可能か明らかにすることを目的とした。

〔対象と方法〕 97年2月から98年11月までに当院で手術をした60歳以上の女性の大腿骨頸部骨折は74例77肢で、このうち DXA 法を施行した52例52肢を骨折群とした。非骨折群として98年4月から98年12月までに人工膝関節置換術を施行し術前に DXA 法を施行した頸部骨折の既往のない女性27例を選んだ。各腰椎 BMD, 大腿骨近位部 BMD の度数分布表を両群で作製し、検討に値する BMD を選定した。それらの BMD の ROC 曲線を作製し正確な指標となる BMD の決定と cut off 値の決定を行った。

〔結果と結論〕 度数分布表は L2-4 BMD, neck BMD, wards BMD において正規分布をなした。これらの ROC 曲線を作製すると neck BMD, wards BMD がより正確な指標といえ、neck BMD の cut off 値は 0.600g/cm^2 （感度76%, 特異度80%）、wards BMD のそれは 0.400g/cm^2 （感度71%, 特異度81%）とすることが可能であった

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