Bone mineral density around femoral stems

DXA measurements in 22 porous-coated implants after 5 years

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In this cross-sectional study the bone mineral density (BMD) close to proximal porous-coated femur stems was measured by DXA 4.5–6 years after the stem implantation and compared to the contralateral non-operated femur in 22 cases. Measuring areas were defined by Gruen's method.

The average precision error varied according to the zone assessed and ranged from 2.2 to 4.9 percent. The median BMD values of the operated femur were in 5 of 7 areas lower than those of the contralateral side. The largest differences were noted in the calcar region and the greater trochanteric region (21 and 20 percent, respectively). No correlation was found between the femoral BMD differences and the stem diameter.

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Noninvasive bone mineral density (BMD) measurements have been improved by recently developed techniques (Genant et al. 1991). Thus, dual-energy X-ray absorptiometry (DXA) has an acceptable precision and accuracy, gives minimal radiation exposure and can, with the appropriate software, be used for measurements of bone mass around metal implants (Kiratli et al. 1992, Kilgus et al. 1993).

Several long-term studies of total hip replacements have shown significant bone resorption in the proximal femur (Charnley and Cupic 1973, Gruen et al. 1979, Thomas et al. 1986).

The Biomet Taperloc® femur stem is a straight-stem titanium component, without a collar. It is porous-coated in the proximal half of the stem only and has shown low subsidence (Wykman and Lundberg 1992).

Our purposes in this cross-sectional DXA study of patients with unilateral Taperloc® proximal porous-coated femoral components more than 4 years after the implantation were: A) to calculate the precision of BMD measurements around femoral implants and B) to measure the relative differences between BMD in the operated and non-operated femurs.

Patients and methods

34 patients with a unilateral non-cemented porous-coated Taperloc® femur stem (from 7.5 to 15 mm in size) in combination with a porous-coated Harris-Galante I acetabular cup, were invited to participate in the study 4.5–6 years after the operation. 9 patients were not interested and 3 were excluded because of major operations performed in the hip region before or after the implantation of the prosthesis. The median age at the time of operation was 47 (31–59) years. Indications for operation were arthrosis (14 cases), idiopathic aseptic necrosis of the femoral head (4 cases) and "others" (4 cases). 2 of the patients with idiopathic femoral head necrosis had drilling of the femoral head before the joint replacement.

Bone mineral measurements were performed with a Hologic QDR-2000 DXA bone densitometer (Hologic Inc., Waltham, MA, U.S.A.) using a pencil beam mode and special hip prosthesis-analyzing software (point resolution 0.1125 cm, line-spacing 0.0559 cm).

BMD was measured in the proximal femur of both legs. The precision study was performed on 13 patients, who were scanned twice on the operated femur with an intermediate repositioning.

The legs were fixed in 25 degrees of internal rotation. All measurements and analyses were made according to the Hologic operators' manual. The algorithm automatically excluded the metallic components of the implant based on the X-ray attenuation of metal relative to bone in the low energy beam. The regions of interest in the femurs were defined according to Gruen et al. (1979) (Figure 1). The compare feature of the software was used to create the regions of interest based on a template, and it was then manually adjusted to account for the anatomy of each individual. BMD (g/cm^2) was obtained for each of

the 7 zones and identical regions in the operated and the nonoperated femurs were compared in 22 patients, including the 13 patients from the precision study. The nonoperated femur of each patient was used as a reference.

For statistical analyses Wilcoxon's paired non-parametric test and Spearman's correlation analysis were used for the comparison of the BMD differences with the stem diameter and the paired Student t-test was used for the comparison of the femoral zone measurements. The chosen level of significance was p 0.01.

The study was approved by the local Ethics Committee and was done in accordance with the Helsinki II Declaration.

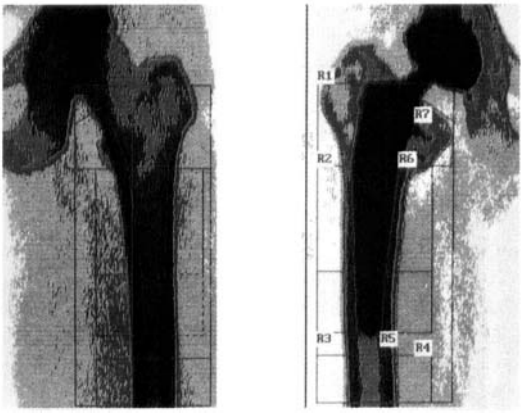

Figure 1. The DXA scan image with measuring zones of the non-operated and the operated hips.

Results

Precision study

The average precision error varied according to the zone assessed and ranged from 2.2 percent in R4 to 4.9 percent in R3 (Figure 1 and Table 1).

Table 1. DXA precision error (percent) in double scanning of 13 patients

	Precision error	
Zone	Average (SD)	Median (range)
R1	2.6 (1.1)	2.9 (0.5–4.1)
R2	4.3 (3.1)	2.9 (0.9–8.7)
R3	4.9 (4.0)	3.5 (0.8–12.3)
R4	2.2 (2.3)	2.6 (0.1–8.6)
R5	2.2 (2.1)	1.2 (0.0–6.3)
R6	3.1 (3.3)	1.9 (0.2–11.3)
R7	2.8 (2.5)	2.5 (0.2–8.3)

Comparative study

The median BMD values in 5 of the 7 Gruen zones (zones R1, R2, R4, R6, and R7) were lower on the operated side (Figure 2). The largest differences were found in R1 (greater trochanteric region) and R7 (calcar region).

There were no correlations between BMD differences (the operated femur BMD minus the non-operated femur BMD) and the stem diameter (r values between –0.14 and 0.37).

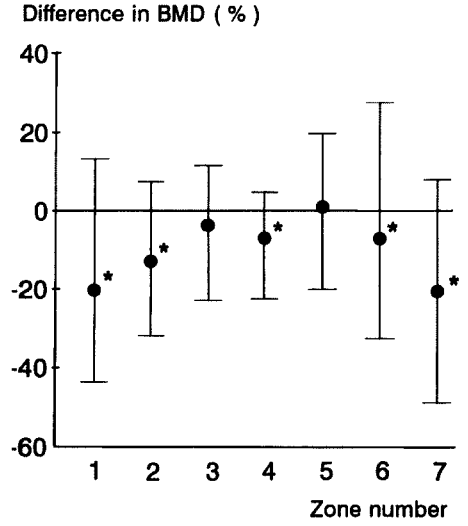

Figure 2. Median measured differences in BMD between the operated and non-operated hips (n 22).
* p < 0.01.

Discussion

The precision errors we found are similar to those reported in an earlier in vivo study (Trevisan et al. 1993). This makes it possible to perform longitudinal DXA studies of BMD changes after implantations.

The largest differences in the BMD between the non-operated and operated femora (up to 21 percent lower values on the operated side) were found in the calcar region and the trochanteric region. Larger differences have been reported in a radiological study with extensively coated prostheses (Engh and Bobyn 1988). In a normal, non-operated control group (Kearns McCarthy et al. 1991), the mean BMD difference in BMD between the 2 calcar regions was between 5 and 11 percent. Masuhara et al. (1994) found that the mean BMD of the affected side was significantly higher than that of the normal side in a

group of patients with unilateral hip arthrosis.

Stress-shielding depends on the size, the stiffness of the stem and the extent of the porous coating (Huiskes 1990, Bobyn et al. 1992). Because of similar density of bone and methylmethacrylate and difficulties in defining the bone-cement interface (Kearns McCarthy et al. 1991), DXA studies have not been able to compare the bone loss around cemented and non-cemented arthroplasties. However, in a recent comparative radiographic study no major influence on the postoperative bone mineral changes was found (Kärrholm et al. 1994).

We found no correlation between the femoral BMD differences and the size of the prosthesis. One explanation could be that the largest median femoral BMD difference was only 21 percent, which is lower than that found in other studies (Engh and Bobyn 1988). The influence of the stem size will therefore be of minor importance in vivo, and not detectable, even in a DXA study. Another explanation could be that the Taperloc® prosthesis, due to its design, transfers the weight in a way that makes the stem size of minor importance. In finite element analysis, it has been found that the interface stresses are affected more by stem shape as a geometric entity and less by stem rigidity, when using a press-fit stem (Huiskes 1990). Our findings could not confirm or refute this report.

The differences in BMD distal to the prosthesis could have been caused by the prosthesis or have been present before the prosthesis was implanted. Such questions should be addressed in future prospective studies.

Acknowledgements

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