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Bone mineral density of the proximal femur after unilateral cementless total hip replacement

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Abstract It was the aim of this study to examine bone mineral density changes in the non-operated contralateral femur of patients undergoing total hip replacement. Bone density in the contralateral femur of 45 patients with an average age of 54 years was measured with the aid of the DEXA technique at one week, 3 and 6 months after total hip replacement. Within the first 3 months there was an average reduction of bone density of 3.9% (3.0%–5.9%). After a further 3 months the average difference was 2.5%.

Résumé Le but de cette étude est de déterminer prospectivement la densité osseuse préopératoire et de la comparer avec les résultats de la densité postopératoire après l'implantation d'une prothése de hanche controlaterale. La densité osseuse de 45 malades (x=54 années) a été mesurée avec la méthode DEXA à la hanche non operée, une semaine, 3 et 6 mois après l'implantation d'une prothese. Nos résultats montrent une réduction de la densité osseuse par l'immobilisation entre –3 et –5,9% (x=–3,9%). Cette différence diminue dans les prochains trois mois à une valeur de –2.5%, qui n'etait plus significative. L'évaluation préopérative montrait une différence de –4.5% en faveur de la hanche qui n'était pas atteinte (12 hanches).

Introduction

Osteodensitometry has for many years been an established procedure for measuring changes in bone mineral density in the spine, femoral neck, distal radius and calcaneus [5, 8, 23]. During the last few years it has become possible to measure periprosthetic bone density following total hip replacement very accurately [2, 12, 17]. There have been several retrospective studies [10, 16] which show a reduction in bone density of 20% to 71% [3] compared to the opposite side. More recent prospective studies cite a loss of bone density in the operated hip of between 25% and 40% [11, 20]. No consideration has however been given to the extent to which the non-operated hip can be used as a reference in retrospective studies. This is clearly important as there are intraindividual bone density differences [5, 13, 21] and the changes depend upon hip pathology [7, 18]. In addition, one of the authors has previously reported an apparent increase in bone density directly following uncemented total hip replacement of up to 20% [17], which suggests difficulty in interpreting results.

Little is known about the bone density changes in the non-operated femur and thus the validity of retrospective studies should be questioned.

The present prospective study is intended to examine bone density changes in the non-operated hip and the extent to which there is a preoperative difference between the diseased and the healthy hips.

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Material and methods

Bone mineral density in the contralateral proximal femur was measured in 45 patients (20 women and 25 men with an average age of 54 years (27–64 years) with severe unilateral osteoarthritis (Kellgren grade 3 and 4), who underwent uncemented total hip replacement during 1993 [9, 15]. Measurements were made using the DEXA method (Lunar DPX-L, Madison, Wisconsin, USA) according to a standardized, previously reported protocol [16]. Postoperative measurements were made 8 days (7–10), 88 days (73–93) and 179 days (168–191). All protheses combined an uncemented custom made femoral stem Type Evolution K (Fehling, Karlstein, Germany) and an uncemented Harris-Galante 1 acetabular component (Zimmer, USA). Mobilization commenced on the second postoperative day with 10 kg load on the operated side. After 2 weeks weight-bearing increased by 10 kg every 2 weeks using crutches, with complete weight-bearing after an average of 14 weeks.

In addition, in order to determine the preoperative difference in bone density between the proximal femur of the healthy and diseased hip, both femora were measured one day prior to surgery in 12 patients (6 women, 6 men). Assessment was made using the

"orthopaedic hip" software and the Gruen Analysis [6], which divides the proximal femur into seven regions of interest (ROI).

The statistical analysis was made after normal distribution had been determined using the Student's *t*-test (α=0.05).

Results

The preoperative measurements showed a reduced bone density in the affected femur in ROI 1 to 6 which averaged 5.9% (3.5% to 8.2%) compared to the opposite side (Table 1). In ROI 7, the diseased femur showed an increase in bone mineral density (BMD) of 6.3% compared to the opposite side; thus resulting in an overall reduction of BMD in the affected hips of 4.5%. The difference is not statistically significant due to the small group and the wide range of results.

The results of the measurements one week, 3 and 6 months postoperatively are given in Table 2. Three months postoperatively there was an average reduction of BMD in the non-operated, total-weight bearing extremity of 3.9% (3.0% to 5.9%), compared to the first postoperative measurement. These differences were significant except in ROI 4. Six months postoperatively the reduced BMD improved in comparison to the first postoperative measurement to an average of 2.5% (+1.7% to –4.2%). These results were not significant except in ROI 7.

Table 1 Preoperative bone mineral density (BMD) in g/cm² of both proximal femurs with percentual difference of the diseased compared to the healthy hip

	BMD-preoperative		Difference (%)
	Healthy	Diseased	
ROI 1	0.879	0.815	–7.3
2	1.348	1.282	–4.9
3	1.835	1.759	–4.1
4	1.933	1.774	–8.2[a]
5	1.866	1.801	–3.5
6	1.443	1.324	–8.3
7	1.223	1.300	+6.3
ROI 1–6	1.551	1.436	–5.9
ROI 1–7	1.504	1.436	–4.5

(*ROI* region of interest; *ROI 1–6* average of ROI 1–6; *ROI 1–7* average of ROI 1–7)
[a] significant (P<0.05)

Discussion

Several retrospective studies use the contralateral side as a reference [3, 10, 16, 19] without knowing the preoperative value and thus possible differences in bone density prior to surgery. Hall [7] found an average difference in the femoral neck in a group without hip or other pathology of 5% (up to 20% in one case). Where there was hip pathology the average difference was about 9%; arthrotic hips usually having higher bone density. Masuhara reported similar results [18]. He found an increase in bone density of 13% in the femoral neck in arthrosis, with a slight decrease (4%) in the greater trochanter and a marked decrease (25%) in the head of the tibia on the same side.

Our results show no increase, but a mean reduction, in bone density of 4.5% in the meta- and diaphysis. We did not however measure only the femoral neck as Hall and Masuhara did [7, 18], but paid special attention to the proximal femur. Years of reduced weight-bearing due to degenerative changes of the hip lead to the reduction in bone density of the femur. The increase of 6.3% in Adams' arch (Table 1) compared to the opposite side corresponds to the results of Hall and Masuhara [7, 18]. This increased density results from bone deposition in the Adams' arch (so called Wiberg sign), especially in the medial cortex [4]. If one ignores ROI 7, the density reduction is 5.9%. We, like Svendsen [21], did not find a statistically significant difference in the bone density of the left femur compared to the right. We found an increase of 3.7% of the left compared with the right in our small sample, while Franck found a statistically significant increase of the left compared to the right of 2% in a large sample of more than 400 patients [5].

Thus, the comparison of the operated hips with the opposite side is not satisfactory in retrospective studies and in determining an absolute bone density loss if the

Table 2 BMD in g/cm² of the healthy hip 1 week, 3 months and 6 months postoperative with percentual difference of measurement after 3 (post 2) and 6 months (post 3) compared to the first measurement (post 1)

	Post 1	Post 2		Post 3	
	BMD	BMD	Diff/post 1	BMD	Diff/post 1
ROI 1	0.898	0.845	–5.9[a]	0.913	+1.7
2	1.457	1.385	–4.9[a]	1.411	–3.2
3	1.916	1.853	–3.3[a]	1.878	–2.0
4	2.013	1.946	–3.3	1.967	–2.3
5	1.951	1.893	–3.0[a]	1.889	–3.2
6	1.481	1.430	–3.4[a]	1.445	–2.4
7	1.238	1.179	–4.8[a]	1.182	–4.2[a]
ROI 1–7	1.565	1.504	–3.9[a]	1.526	–2.5

(*ROI* region of interest; *post 1* 1 week postoperative; *post 2* 3 months postoperative; *post 3* 6 months postoperative; *Diff/post 1* difference to the post 1-measurement in percent)
[a] significant (P<0.01)

preoperative values are not known. And only prospective studies can provide a realistic picture of the bone density loss, since differences of up to 20% in individual cases are reported as being within the normal range [7, 17]. Adolphson [1] found preoperatively a reduction of 1% in BMD in the mid-femoral shaft area of the affected side, of 11% in the distal femur and of 14% in the proximal tibia; which was confirmed by Masuhara [18]. After 3 and 6 months Adolphson reported no changes on either side in the middle and distal femoral shaft. A reduction of bone density was however found in the proximal tibia of the non-operated side of 3% after 3 months and 8% after 6 months with constant BMD on the operated side.

In spite of early mobilization we found a significant loss of bone density on the non-operated femora of 3.9% after 3 months compared to the first postoperative measurement. After another 3 months, there remained a reduction in bone density of 2.5% compared to the first postoperative measurement. It was interesting that even such a short period of immobilization resulted in a significant reduction in bone density in the non-operated limb. Krølner [14] found a reduction in bone density in the lumbar spine of 4% per month in patients with acute back pain treated by bed rest and symptomatic mobilization. This emphasises that bone mineral balance is very sensitive, reacting to even slight changes in activity. Krølner [14] also recorded complete recovery of BMD 4 months after intensive physiotherapy; while we still noted a loss of 2.5% in the non-operated side after 6 months. This difference was, however, not significant as the standard error in the technique of measuring bone density is between 2% and 2.5% [22, 12].

Thus we conclude that the non-operated extremity cannot serve as a comparison when measuring bone mineral density after total hip replacement.

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