

Changes in bone mineral density (BMD) around the cemented Exeter stem

A prospective study in 18 women with 5 years follow-up

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Background and purpose THA changes the pattern of strain distribution in the proximal femur. We quantified the changes in BMD for 5 years after insertion of the cemented Exeter stem in women.

Methods 18 women aged 55–79 years, undergoing unilateral THA with the cemented Exeter stem, were included in the study. The BMD was measured in 7 femoral regions of interest according to Gruen, and the contralateral hip and spine using dual-energy X-ray absorptiometry postoperatively, at 18 and at 60 months of follow-up. Results were tested using Wilcoxon matched-pairs signed-rank test.

Results During the first 18 months, a significant decrease in BMD was seen in zones 2, 3, 6, and 7. No significant changes were seen in zones 4 and 5, in the contralateral hip, or at the spine. In zone 1, there was a small but significant rise in BMD. From 18 to 60 months, we observed a statistically significant rise in BMD in all zones except 4 and 7. Despite this, the total periprosthetic BMD decreased during the follow-up relative to the immediate postoperative situation. There was no significant reduction in BMD in the contralateral hip. In the spine, we observed a significant rise in BMD.

Interpretation 18 months after THA, BMD had decreased in Gruen zones 2, 3, 6, and 7. The bone loss was similar to that seen after other implants and appears to be related to the changes in stress pattern within the proximal femur. At 5 years, BMD had increased again in these zones. It remained lower than baseline, however.

Loss of bone mass in the proximal femur can reduce the survival of a total hip arthroplasty (THA) (Kobayashi et al. 2000). Following both cemented and uncemented THA, a loss of bone mass is seen around the stem; both the dimensions of the stem, the material of the stem, and the fixation method seem to affect the loss of bone (Huiskes 1990, Bobyn et al. 1992). Reduced strength of bone around the stem after THA (McCarthy et al. 1991) might cause loosening of the stem and increase the risk of fractures around the stem after a fall. Dual-energy X-ray absorptiometry (DXA) is a well-documented method of monitoring after THA (Marchetti et al. 1996, Spittlehouse et al. 1998) and detects even small changes in bone mineral density (BMD) around the stem (Kilgus et al. 1993, Kröger et al. 1996). Most previous publications on periprosthetic BMD describe patients with uncemented THA. Venesmaa et al. (2003) found that the largest changes in BMD occurred during the first 6–12 months following THA; after more than 12 months, only minor changes were seen. The largest changes were seen in the calcar region and women lose significantly more bone in the periprosthetic region than men (Venesmaa et al. 2003). In this paper, we describe changes in periprosthetic BMD in the proximal femur following THA with the cemented Exeter stem in women. The Exeter stem has been one of the most frequently used cemented stems in Denmark for many years (Lucht 2000).

Patients and methods

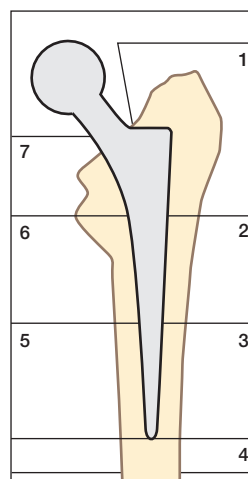
We originally included 26 women (aged 55–80 years on the day of surgery) who underwent a primary THA with cemented Exeter stem at Middel-fart Hospital in the period December 1998 to February 2000. The indication for THA in all patients was primary arthrosis. Patients with diseases known to affect bone metabolism (i.e. thyrotoxicosis, hyperparathyroidism, osteomalacia, or renal osteodystrophia) or who were being treated with bisphosphonate, vitamin D, systemic estrogen, or systemic glucocorticoids were excluded.

The patients were DXA-scanned postoperatively and again after 18 months. Results of the first 18 months of follow-up in these 26 patients have been published (Damborg et al. 2005). In the fall of 2003, we tried to contact these 26 women—both in writing and by telephone—to offer them a follow-up DXA scan 60 months after surgery. 2 had died, and of the remaining 24 patients, 18 (aged 55–79 years on the day of surgery) agreed to the 60-month follow-up scan. None of the 6 patients who were lost to follow-up had been revised or had experienced complications with their THA. So we report data from 18 patients who were followed for a total of 60 months.

We used a posterolateral approach without the use of a trochanterosteotomy. The femoral implant was the sleeveless, polished, tapered Exeter stem. Cementation was done using Simplex cement and second-generation cementation techniques (Kale et al. 2000). All patients were trained and instructed by physiotherapists. They were allowed full weight bearing from the first postoperative day. There were no postoperative complications. All had a well-functioning arthroplasty at follow-up.

BMD was measured on the 10th (8–14) postoperative day, after 18 (17–22) months and after 60 (60–63) months using DXA scan. Measurements were all made using the same Hologic QDR 2000 scanner. Patients were examined in the supine position. The thigh was fixed in neutral position using a knee- and foot-plate to minimize inaccuracy (Damborg et al. 2005).

The coefficient of variance (CV) was 1.5% measuring BMD over the whole hip region and columna lumbalis and it was 2.1% in collum femoris (Abrahamsen et al. 2003). On the operated side, stem, cement coating, bone, and soft tissue were all in



Drawing of a DXA scan of the proximal femur, showing the 7 Gruen zones around a femoral stem.

the field of scan. We used metal-removal software that automatically excludes the stem from the calculations, but includes the cement. The entire periprosthetic region was measured “overall” and the periprosthetic bone was subdivided into 7 regions of interest (ROIs) according to Gruen (Figure). All analyses were done by the same investigator. Intra- and interobserver variance (CV) was found to be $1.0 \pm 0.4\%$ and $1.7 \pm 0.7\%$ ($n = 11$). To check for any migration of the stem during the observation period, we measured the subsidence of the stem proximally and measured the distance from the top of the trochanter to the tip of the stem on the DXA scans. The distances measured were correlated to the known length of the stem to correct for different enlargements in the different scans. BMD was measured in the contralateral hip and the lumbar spine to correct for age-dependent changes in BMD (Hannan et al. 2000).

All participants gave their consent in writing after receiving verbal and written information about the study. The study was approved by the regional ethical committee (Videnskabs Etisk Komité for Vejle og Fyns Amter (VF 19980105)).

Statistics

Wilcoxon matched-pairs signed-rank test (paired observations) was used in the statistical analysis. This method was chosen to look specifically at three different periods of the study (i.e. baseline to

BMD at baseline, after 18 months, and after 60 months. Values are mean / median (range). Differences were tested using Wilcoxon's matched-pairs signed rank test

Region of interest (ROI)	BMD (g/cm ²)		
	Baseline	18 months	60 months
Gruen zone			
1	0.89 / 0.87 (0.60–1.34) ^a	0.93 / 0.87 (0.72–1.33) ^d	0.99 / 0.94 (0.77–1.32) ^h
2	1.49 / 1.55 (0.99–1.91) ^b	1.41 / 1.41 (0.90–1.87) ^d	1.47 / 1.45 (0.94–2.03)
3	1.77 / 1.74 (1.45–2.04) ^c	1.70 / 1.70 (1.45–2.09) ^e	1.77 / 1.76 (1.50–2.19)
4	1.90 / 2.02 (1.48–2.34)	1.90 / 1.96 (1.48–2.11)	1.96 / 1.96 (1.54–2.47)
5	1.64 / 1.63 (1.45–1.83)	1.62 / 1.60 (1.40–1.82) ^d	1.71 / 1.72 (1.45–1.97) ^f
6	1.39 / 1.35 (1.02–1.93) ^c	1.21 / 1.15 (0.93–1.77) ^d	1.28 / 1.27 (0.90–1.82) ^f
7	1.41 / 1.43 (0.52–1.91) ^c	1.21 / 1.14 (0.72–1.79)	1.25 / 1.23 (0.68–1.97) ^g
Periprosthetic region	1.38 / 1.37 (1.15–1.58) ^b	1.32 / 1.34 (1.11–1.53)	1.30 / 1.25 (1.06–1.58) ^f
Contralateral hip	0.83 / 0.80 (0.51–1.08)	0.81 / 0.75 (0.55–1.12)	0.78 / 0.73 (0.57–1.02)
Spine	0.95 / 0.95 (0.71–1.22)	0.96 / 0.95 (0.77–1.23) ^d	1.02 / 0.95 (0.86–1.30) ^g
Significant difference between baseline and 18 months: ^a p < 0.05; ^b p < 0.01; and ^c p < 0.001.			
Significant difference between 18 and 60 months: ^d p < 0.01; and ^e p < 0.001.			
Significant difference between baseline and 60 months: ^f p < 0.05; ^g p < 0.01; and ^h p < 0.001.			

18 months, 18 months to 60 months, and baseline to 60 months.). Differences were considered significant at p-values less than 0.05.

Results (Table)

During the first 18 months of observation, we found a significant fall in BMD in zones 2, 3, 6, and 7, while there was no significant change in BMD in zones 4 and 5 in the contralateral hip and in the lumbar spine. In zone 1 we found a small, but statistically significant, rise in BMD.

In the period from 18 to 60 months we found a significant rise in BMD in all Gruen zones, except for zones 4 and 7 where we found no significant changes in BMD. Overall, we found a periprosthetic fall in BMD in most of the zones, followed by a smaller and slower—but statistically significant—rise in BMD. However, compared to baseline directly after surgery, there was a fall in the total periprosthetic BMD over the 60-month period. In the lumbar spine we found a small, but statistically significant, rise in BMD from 18 to 60 months. This rise was still significant when testing over the whole period. There were no significant changes in BMD in the contralateral hip during the observation period. We found no major migrations or subsidence of the stem during the 60 months of observation.

Discussion

We found that after the insertion of a cemented Exeter stem, substantial changes to the periprosthetic BMD in the proximal femur follow. These observed changes are in the same range as changes seen after uncemented THA (Venesmaa et al. 2001, 2003, Rahmy et al. 2004). During the first 18 months of follow-up, the total periprosthetic BMD decreased. Loss of periprosthetic BMD following THA is well known from other studies with different stems, or different fixation (Gehrchen 1999, Glyn-Jones et al. 2003, Venesmaa et al. 2003, Bodén et al. 2006). We found local variations in the changes in BMD around the stem, with the greatest reduction in the calcar region. These findings are similar to what has been described previously (Venesmaa et al. 2003, Damborg et al. 2005) and they are probably a consequence of stress shielding due to distal load transfer between the prosthetic component and the host. The overall pattern of migration of the Exeter stem has been shown to be one of subsidence and rotation into valgus (Alfaro-Adrián et al. 2001).

During the second period of follow-up (i.e. 18–60 months), we found a rise in BMD in all Gruen zones except zones 4 and 7. This rise in BMD could be seen as an expression of new bone formation following the operation and reconvalescence. Over the total 60 months of follow-up, the total

periprosthetic BMD was seen to fall; this is again similar to what has been described previously. Several studies have shown that the postoperative fall in BMD is greatest during the first 6–12 months, after which changes in BMD are expected to be close to the normal age-dependant bone loss of approximately 1% (Hannan et al. 2000).

It has been stated previously that cementation, and the components of cement, give artefacts in the measurements of BMD (Venesmaa et al. 2003). Some authors have therefore tried to subtract the cement mantle in the scan (Marchetti et al. 1996), while others have found this impossible (McCarthy et al. 1991, Cohen and Rushton 1995). In our study, we were unable to distinguish between bone and cement mantle. One could expect that pressurized cement would give rise to falsely enlarged values of BMD close to the cement mantle. However, BMD in the cement mantle will not change over time (Kröger et al. 1996). In longitudinal studies, changes in BMD will—independently of the possible artefact from the cement mantle—thus be an expression of true changes in periprosthetic BMD.

Venesmaa et al. (2003) followed 15 patients (10 women) for 5 years after cemented THA. They found a significantly greater loss of periprosthetic BMD in postmenopausal woman than in age-matched men after 5 years. Our patients were all women, and the fall in periprosthetic BMD that we observed was no larger than the values reported from similar examinations that have included both genders.

In the lumbar spine we found a small, but statistically significant, rise in BMD from 18 to 60 months; this rise was still found to be significant when testing over the whole period. One explanation of this could be that patients suffering from osteoarthritis of the hip are more likely to be suffering also from osteoarthritis of the lumbar spine; thus, an aggravation of this condition might yield greater BMD values. This is supported by results from the Baltimore longitudinal study of aging where individuals with osteoarthritis of the hips and knees were found to have higher adjusted levels of bone mineral density (Hochberg et al. 2004).

We followed our patients for 60 months and found a rise in BMD in 5 out of 7 zones during the last 3.5 years of observation (i.e. 18–60 months). Thus, we cannot exclude the possibility that with

longer follow-up, BMD would be found to normalize.

We have not found any studies that have found a correlation between BMD values and loosening of the THA. All our patients had a well-functioning THA after 60 months. None had been revised or had experienced complications with their THA. Thus, based on this study one cannot say whether a fall in periprosthetic BMD predicts failure of the THA or associates it with failure.

Contributions of authors

FD took part in all aspects of the study and wrote the paper. NN performed the DXA investigations and contributed in manuscript preparation. HRIJ recruited patients, assisted in preparing the protocol, and proofread the manuscript. BA supervised DXA investigations, assisted in preparing the protocol, and proofread the manuscript. KB supervised the statistical analyses and proofread the manuscript.

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