Bone mineral content changes around stable cementless total hip arthroplasty

A four-year follow-up study

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Summary: In this prospective study we followed the bone mineral content (BMC) changes over time at seven distinct well defined bone Zones (1-7), around the uncemented Zweymueller total hip arthroplasty (THA) components, using dual energy x-ray densitometry, and a roentgenographical analysis close to the tip of the Zweymueller stem, to measure any postoperative cortical thickness changes. A homogenous group of 36 female patients, average age of 55 years, with primary hip osteoarthritis was studied. The BMC-measurements were made preoperatively, 2 weeks, one year and four years postoperatively. The BMC-changes in this study were shown to be statistically significant at the Zones 1, 3, 5, 6 and 7 (P-values 0.05-0.01), whereas at the Zone 2 they were not. The BMC-changes over time for all Zones of interest were not related to the age of the patients. We believe that the BMC-reduction, observed at the Zones 2 to 7, immediately after implantation of the Zweymueller THA, should be related to the intraoperatively removed bone. Conclusions: (1) the Zweymueller screw socket finds its definitive anchorage immediately postoperatively at the medial and distal thirds of the acetabulum and remains stable over time, without any further bone mineral content changes; (2) the Zweymueller stem finds its main anchorage within the distal femoral cortex and remains stable up to 4-year observation, without significant bone mineral content changes; and (3) the Zweymueller stem finds two additional points of fixation within the mass of the greater and lesser trochanter, where it induces a continuous bone turnover with bone trabecula thickening, which probably extends more than 4 years.

Key words: Bone mineral changes — Hip prosthesis

DEXA is a noninvasive method of bone mineral content and density measurement [1, 3, 5, 8, 14]. The versality, precision and accuracy of the latest densitometry techniques make the investigation on the affect of bone mass after implantation of a total hip arthroplasty increasingly feasible [2, 4-7, 9, 12, 13]. It is the purpose of this prospective study to investigate the course of the periprosthetic bone mass changes after implantation of an uncemented Zweymueller THA over time.

Material and methods

In order to follow the course of bone mineral content changes around the screw socket and stem of the uncemented Zweymueller THA over time, a prospective study was conducted over a period of 4 years, with use of DEXA. Thirty-six consecutive female patients, average age 55 years, SD=9, range 40-69 years suffering from primary osteoarthritis of the hip, received each a Zweymueller THA. The inclusion criteria were: (1) primary hip osteoarthritis, (2) no previous operation in the hip of interest, (3) no history of infection in the hip, (4) no previous intake of ostrogen, cortisone, calcitonin, or other medication for osteoporosis in the last two years, (5) no clinical or radiological signs of loosening or migration of either socket or stem of the prosthesis up to the last observation 4 years postoperatively, (6) blood sedimentation rate and blood count analysis within normal limits during the four time points of BMC-measurements, and (7) all operations were performed by the same surgeon (first author) using always the same operative technique [6]. The shaft was always implanted in the posterior third of the femur, within the mass of the greater trochanter (Fig. 1) after removal of approximately one third of its cancellous bone, in order to pass the proximal lateral flange of the Zweymueller stem (Fig. 2). Seven Zones (Fig. 3a, b), which have been already described6, three in the acetabulum around the socket (1 to 3) and four in the femur around the stem (4 to 7) were selected for measuring the bone mineral content [6]. Scans were analyzed in the following manner. A manual analysis was performed in the following average dimensions, which were always exactly the same for every hip over time, for each Zone (Fig. 3a, b): (1) Zone 1 [length 1.20 cm, width 2.70 cm], (2) Zone 2 [length 1.50 cm, width 1.20 cm], (3) Zone 3 [length 1.20 cm], (4) Zone 4 [length 2.40 cm, width 1.20 cm], (5) Zone 5 [length 1.50 cm, width 0.90 cm], (6) Zone 6 [1.50 cm, width 1.20 cm] and (7) Zone 7 [length 3.30 cm, width 1.20 cm]. Exactly the same seven areas of interest (Fig. 3a, b) were always taken to measure the bone content (g) by using the specific software. The standard pilot points which were taken were: (a) the tip of the Zeymueller stem, (b) the level of the tip of the greater trochanter and (c) the level of the lesser trochanter (Fig. 4). Always using exactly the same method, four measurements were performed over a period of 4 years after implantation of the THA: (1) immediately preoperatively, (2) 2 weeks postoperatively, (3) one year postoperatively, and (4) 4 years postoperatively in each particular patient and in all the seven Zones of interest for both operated and non-operated hips. The results of the BMC-measurements were confined to the operated hips, in order to study any changes of BMC over time. Periprosthetic acetabular and femoral BMC was determined with the use of a Norland XR-26 x-ray bone densitometer (Norland, Wisconsin, U.S.A). Patients were examined, supine on the table with both legs secured in precisely the same degree of rotation.
Schematic representation of the operative technique for implantation of the Zweymueller stem. Note the resection of great amount of bone from the intertrochanteric area as well as from the internal femoral cortex distally of the femur (20° internal rotation) and the same antversion of the femoral neck to bring both patellae to the neutral position, in a specially fabricated splint applied bilaterally and symmetrically [6]. Dual energy xray absorptiometry software recently has been modified to allow the measurement of bone mineral content of periprosthetic bone adjacent to metal implants [11]. The scans of the operated hips in the four different time points of observation, were compared to each other (paired t-test) in each of the 7 Zones in the following manner: (1) preoperatively to 2 weeks, one and four years postoperatively, (2) 2 weeks postoperatively to one and four years postoperatively, and (3) one year postoperatively to 4 years postoperatively. All data was analyzed over time with use of one-way analysis of variance (ANOVA) (Table 1). The reproducibility of the technique was assessed in 34 out of 36 operated hips and in an additional 20 non-operated on hips and in all the seven previously mentioned Zones (Fig. 3a,b). The Pearson coefficient (r) of variation of BMC (Zones 1 to 7) was determined by three scans on each subject over a 21-day period were r1=0.87, r2=0.76, r3=0.9, r4=0.834, r5=0.865, r6=0.86 and r7=0.93. Using the same fixation method as for the DEXA measurements, the following roentgenographical analysis was performed at the Zones 6 and 7, both preoperatively and immediately postoperatively in order to measure quantitative femoral cortical bone mass changes: 13 cm below the tip of the greater trochanter, perpendicular to the longitudinal axis of the femur, the thickness of (a) femur and (b) each femoral cortex at the same areas, corresponding to the Zones 6 and 7 was measured (Fig. 4). Therefore, in order to avoid any magnification error due to any difference in rotation of the femur, the thickness of each cortex was divided by the total...