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DEXA evaluation of total hip arthroplasty with neck-preserving technique: 4-year follow-up

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Abstract Periprosthetic bone remodeling, and its evaluation, are the keys of long-term survival of cementless total hip arthroplasty. Dual energy X-ray absorptiometry (DEXA) is the most accurate method to measure bone mineral density, evaluating the effects of bone-prosthesis interactions. We studied, 4 years after implantation, 10 patients who underwent total hip arthroplasty with the CFP prosthetic stem and TOP acetabular cup (Waldemar Link, Hamburg, Germany). Our results demonstrate minimal periprosthetic bone loss compared to that normally observed with conventional stems. A few cases exhibited an increase in BMD. We believe that primary stability, prosthetic design, preservation of natural neck anteversion and off-set, better function related to muscle lever arm, and physiological bone loading with natural stress distribution are the keys of this succesful mini-invasive total hip replacement system.

Key words DEXA • Bone remodeling • Total hip arthroplasty

Introduction

Long-term survivorship of total hip arthroplasty is strictly related to the bone-host interaction, where bone remodeling is the main factor [1]. The evaluation of bone mass surrounding the implant is the most reliable method, starting from the common observation that bone reacts to stable and well functioning implants with bone apposition according to Wolff's law, while bone resorption is the typical response to an unstable and mal-loading implant [2– 4].

In the last ten years, dual energy X-ray absorptiometry (DEXA) has become more popular among investigators of bone mineral density (BMD) around femoral stems, making it possible to quantify the bone filling, the space between bone and stem (interface bone growth), and the dynamic process of reabsorption, apposition and transformation which involves the whole bone segment containing the implant (bone remodeling) [5–7].

The first experience with DEXA started in the early 1990s, with observations regarding application and limits and then moving to clinical trials [8, 9]. The new concept of minimally invasive surgery in the field of total hip arthroplasty means, in our opinion, not only a small incision, but also a physiological load transfer from the stem to the bone with a conservative stem design, like CFP prosthetic stem (Waldemar Link, Hamburg, Germany).

In this paper, we describe our mid-term (4-year) results, in terms of BMD measurement, with the CFP stem.

Patients and methods

We studied 10 patients (7 men) aged 51–69 years, operated by the same surgeon for coxarthrosis with CFP stem and TOP acetabular cup (Waldemar Link, Hamburg, Germany). In all cases, a direct lateral approach was used. The postoperative regimen included immediate mobilization, partial weight bearing with crutches for 1 month, followed by complete weight bearing (Fig. 1a-c).

All patients had antibiotic prophylaxis for a 36 hours prior to surgery with first-generation cephalosporin, and prophylaxis against deep vein thrombosis with low molecular weight heparin for 36 days afterwards.

The CFP prosthetic stem is made of titanium alloy with proximal periapatite coating, allowing femoral neck preservation as well as natural anteversion and antetorsion, resulting in immediate primary stability, early functional recovery with full range of motion, and secondary fixation by bone growth and remodeling.

The study protocol included serial DEXA examinations: the first within the first two postoperative weeks, the second at one month, the third at four months, the fourth at one year, and the final evaluation at four years.

An X-ray densitometer (QDR 100/w; Hologic, Woltham, USA), was used by the same observer who also collected all data. Measurements were made on posteroanterior radiographs in all 7 Gruen's zones. We assumed that with conventional implants the average bone loss was between 15% and 45%, mainly in the proximal areas, with the crisis period at 2–3 months [5]; subsequent partial recovery usually occurs at two years, with a further bone loss every year of 1.0%–1.5%.

Results

Four years after surgery, the 10 patients had good clinical and radiographical outcomes, evaluated on the Harris hip scale (the mean score increased from 41 points preoperatively to 92 points) and on conventional radiography (no stem modifications, no radiolucent lines) (Fig. 2a, b). The most important finding concerned the change in bone mineral density, which ranged from +1.9% to -16.1%. The main bone loss in our group was observed in Gruen's zones 1 and 7, corresponding to the upper femoral neck regions where the cancellous bone is more present, and in zone 4, at the stem's apex where we need stem centralization without wedging. Conversely, the maximum increase in bone mineral density was measured in zones 3, 5 and 6, when physiologically the resulting forces are transmitted during weight-bearing.

Fig. 1a-c *Radiographic evaluation of 55-year-old man.* **a** Preoperative anteroposterior view. **b** Preoperative lateral view. **c** Post-operative anteroposterior view

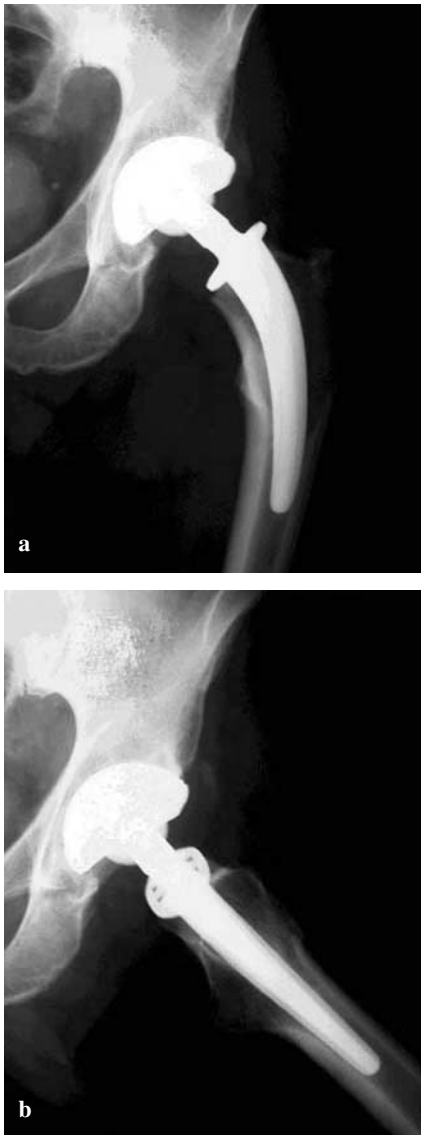

Fig. 2a, b *Radiographic evaluation after 4 years.* **a** Anteriopo-sterior image. **b** Lateral image

Discussion

In hip replacement surgery, good long-term results can be predicted and expected after realizing an "integrated system" between the prosthesis components and the host bone [1, 3, 4]. This can be realized, at the beginning, choosing reliable cups and stems; correctly inserting them in terms of surgical technique; obtaining primary stability with cement or without (the so-called press-fit technique in cementless total hip arthroplasty). Long-term survival of the implants is directly related to the bone's adapting (i.e. bone remodeling) at the cup or stem, mainly in cementless configuration: in the presence of a well functioning hip with a stable implant, the host bone reacts in terms of bone apposition around the components (bone ingrowth) and preservation of mineral contents; this is important in the cortical load-bearing parts.

DEXA is, possibly, the best evaluation method of bone density around prosthetic uncemented stems, measuring and quantifying the bone-prosthesis system [6, 9]. The stem's insertion in the femoral medullary canal implies a certain cortical bone loss, mainly in the early postoperative period (2–3 months), when less function and weight-bearing are expected. Moreover, the most evident demineralization is observed in the proximal femur, Gruen's regions 1 and 7, while an increase in bone mass starts at month 3 or 4, consolidating at one year but still present at four years as our study demonstrated.

This is, in our opinion, due to the mini-invasive approach we used for primary total hip replacement. This means not only a small incision, but also femoral neck preservation, as well as physiological anteversion and offset, and muscles lever arm with better function. Good range of motion and load transfer to the femoral cortical bone stimulate bone remodeling, with bone apposition around the stem and good mineralization of the femur, conditions for expected good long-term results.

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