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Original article

Difference in periprosthetic acetabular bone mineral density: Prior total hip arthroplasty: Osteonecrosis of the femoral head versus primary osteoarthritis

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ABSTRACT

Background: Total hip arthroplasty (THA) could be associated with a higher failure rate in patients after osteonecrosis of the femoral head (ONFH) compared to a patient population with primary osteoarthritis prior THA, especially regarding the acetabular component. One major reason could be the compromised acetabular bone quality. Therefore, we performed a retrospective case matched study to assess: 1) Is there a difference in periprosthetic bone mineral density between patients with an ONFH prior THA and controls? 2) Do patients with an ONFH prior THA have a lower bone mineral density compared to controls? 3) Which region in the periprosthetic bone stock is more likely to present differences in periprosthetic bone mineral density between both groups?
Hypothesis: We hypothesized that there is a poorer bone mineral density (BMD) in the periacetabular bone stock in patients with an ONFH prior THA compared to controls receiving a THA due to primary osteoarthritis.
Patients and methods: We compared the BMD of 50 patients with ONFH to 50 controls with primary osteoarthritis prior THA using the same implant in mean 5 years after surgery by means of dual energy X-ray absorptiometry (DXA). We analysed 3 acetabular ROIs according to DeLee and Charnley in a modified measurement technique.
Results: In ROI 3, representing acetabulum's upper aspect, statistically significant lower BMD values for the ONFH group could be found ($P < 0.05$). No difference was found for the modified ROIs 1 and 2 (respectively medial and lower acetabulum).
Discussion: The results indicate a poorer periacetabular BMD in patients with ONFH prior THA, which might be responsible for premature loosening of the acetabular cup in THA. Due to a lack of literature, further clinical investigations are required to confirm our results.
Level of evidence: III: retrospective case-control study.

1. Introduction

Clinical longevity of total hip arthroplasty (THA) depends on their osseointegration, which is influenced by the load, the characteristics of the implant and the bone-implant interface, as well as by the quality and quantity of the surrounding bone [1]. Aseptic loosening due to periprosthetic osteolysis is the most frequent known cause of implant failure [1]. Osteonecrosis of the femoral head (ONFH) remains a challenging disease, as it usually leads to the destruction of the hip joint in young patients between their third and fifth decade of life [2]. Despite attempts to preserve the hip joint in early stages, THA is indicated once the femoral head has collapsed and the articulation is compromised (ARCO stages III and IV) [2]. The results of THA after both, ONFH and primary osteoarthritis are controversially discussed in literature. Some authors report comparable short-term results of cementless total hip arthroplasty in patients with osteonecrosis of the femoral head compared to patients suffering from primary osteoarthritis prior THA [3]. Other authors suggest poorer results of THA in patients with ONFH compared to patients with primary osteoarthritis prior THA, both with and without the use of cement fixation [4–7]. High level of activity in younger patients and increased body weight are stated as reasons for premature loosening of the acetabular component [4–7]. However, other reasons for this higher failure rate of THA in ONFH are often underestimated such as qualitative and quantitative bony acetabular deficiency subsequent to the collapsed femoral head,

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reduced weight bearing during long periods, systemic diseases and defects in mineral metabolism associated with the use of corticosteroids [8]. Other authors underline that especially acetabular loosening remains one of the most frequent reasons for revision surgery in patients with prior ONFH with or without cement fixation [9–11]. Furthermore, in previous radiological and histological investigations, a reduced bone quality was found in the femoral head, the intertrochanteric and metaphyseal region in patients suffering from ONFH [12,13]. An increased gene expression of factors regulating bone formation and remodeling in the femoral head and neck in patients with ONFH could be found [14]. A decreased bone mineral density (BMD) in the trochanteric region and the proximal femoral canal of the affected side compared to the healthy contralateral side was found as well [15]. In our previous investigation, no difference in periacetabular bone mineral density between navigated and conventional THA could be found using dual energy X-ray absorptiometry (DXA) [16]. DXA is regarded as an accurate method to evaluate BMD and to evaluate bone remodeling around hip prostheses [3,17–19]. In many previous studies, DXA has been used to investigate periprosthetic BMD and bony ingrowth after THA [20–24]. Compared to conventional x-rays, DXA is stated to be more sensitive to detect small changes in periprosthetic bone mineral density [25]. Sabo et al. [26] found that DXA is a useful method for analyzing changes of mineralization around the cup in THA. In some radiological investigation, the bone changes produced by osteonecrosis of the hip was quantified and BMD analyzed by means of DXA according to DeLee and Charnley (ROI 1–3) [27,28]. The current study investigates a possible difference in periprosthetic acetabular bone mineral density between patients with ONFH prior THA and controls. In literature, this is the first study analyzing the periacetabular bone stock using DXA in patients of both groups. This case matched study was designed to assess:

- is there a difference between patients with ONFH prior THA and controls?
- are patients with an ONFH prior THA lower in periprosthetic acetabular bone mineral density?
- which ROI's are more likely to detect a significant difference in periprosthetic acetabular bone mineral density between both study groups?

We hypothesize that there is a poorer periprosthetic acetabular bone stock in patients who have had an ONFH prior THA compared to patients who received a THA due to primary OA of the hip.

2. Patient and methods

2.1. Patients

This matched-pair analysis was conducted after authorization by the Institutional Ethical Board of the Medical University of Regensburg (No. 14-101-0108). Written informed consent for participation in this investigation was obtained from all patients. One hundred patients were included, 50 who had received a unilateral THA due to primary osteoarthritis and 50 who had received a THA due to ONFH were included. There were 46 men and 54 women with a mean age at the time of surgery of 63 years (range 41–85). The matching criteria age, gender, body mass index (BMI), treated side and sex were similar in both groups (Table 1). All patients were recruited from a cohort of 400 patients. Exclusion criteria were imposed in order to avoid changes in BMD which were not related to ONFH: rheumatoid arthritis, prior injuries or surgeries on the hip, intake of oestrogen, calcium, vitamin D, calcitonin, iode containing medication or any other medication for osteoporosis before, during or after performed surgery.

Table 1
Demographic data of the femoral head necrosis and the primary osteoarthritis group presented in means, standard deviation and range.

	ONFH ($n = 50$)	Primary OA ($n = 50$)	P-value
Sex	28 female, 22 male	25 female, 25 male	1.0
Age (years)	63.6 (11.9, 37.6–87.7)	61.6 (9.3, 43.9–77.5)	0.6
Weight (kg)	80.4 (14.65, 53–117)	77.6 (14.1, 60–115)	0.7
Height (m)	1.68 (0.09, 1.50–1.85)	1.68 (0.08, 1.52–1.88)	0.9
BMI (kg/m^2)	27.9 (4.01, 19.0–35.0)	27.4 (4.3, 20.0–45.0)	0.8
Treatment side	24 left, 26 right	29 left, 21 right	0.3

ONFH: osteonecrosis of the femoral head; OA: osteoarthritis; BMI: body mass index.

We identified 136 patients (68 matched-pairs), which met our inclusion criteria 5 (3.8 to 6.1) years after surgery. We excluded patients with a known history of osteoporosis and/or the use of bone remodelling drugs (calcitonin, vitamin D, oestrogens or iodine containing medication) pre- or postoperatively. During routine follow-up, all patients underwent a radiological examination. Four patients were excluded due to poor quality of the DXA scan. Five patients had died and 24 patients were not able to return to the hospital for examination. All in all, 17 pairs had to be excluded from analysis. In total, we were able to analyse 102 patients (51 pairs) and decided to include 100 patients (50 pairs) in the study protocol.

2.2. Methods

THA in all patients was performed in the lateral decubitus position using a minimally-invasive single-incision anterolateral approach. THAs were performed by a single orthopaedic surgeon from the Orthopaedic University Hospital of Regensburg/Germany with experience of more than 500 THAs. Press-fit acetabular components, uncemented hydroxyapatite-coated stems (Pinnacle cup, Corail stem, DePuy, Warsaw, IN), polyethylene liners and metal heads with a diameter of 32 mm were used in all patients. The target acetabular component position for all patients was within the "safe zone" as defined by Lewinnek et al. ($40^\circ \pm 10^\circ$ inclination and $15 \pm 10^\circ$, anteversion) [29].

2.3. Methods of assessment

All patients underwent DXA scanning (Lunar DPX; GE Healthcare General, Fairfield, USA) of the acetabulum during the follow-up examination using the metal removing hip scanning mode. No baseline value of preoperative bone mineral density was available. Due to ethical restrictions, a DXA scan of the contralateral side could not be performed. According to the manufacturer's instructions, patients were placed in the supine position, the leg in slight internal rotation. The leg was attached to a positioning device. The acetabular scans were examined using modified zones according to DeLee and Charnley (ROI 1–3) [27,28]. We performed a slight modified measurement technique due to a better visualization of the DXA scans (Fig. 1). All measurements were performed by one blinded and independent observer and interpreted according to El Maghraoui and Roux [30].

2.4. Statistical analysis

Data were presented as means and standard deviation or as numbers for qualitative variables. The BMD values between the two groups were compared with the Mann-Whitney test (continuous variables). All analyses were performed using SigmaPlot 11.0 (Systat Software Inc., Chicago, IL, USA). Statistical comparisons were made at a 0.05 level of significance.