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HIP ARTHROPLASTY

Cementless short stem hip arthroplasty METHA® as an encouraging option in adults with osteonecrosis of the femoral head

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Abstract
Introduction The implantation of a total hip arthroplasty is the standard treatment for patients with progressive osteonecrosis. However, there is uncertainty about the type of arthroplasty that provides the best outcome and whether short stem arthroplasty represents a reasonable alternative for young patients in order to have more options in case of revision. This uncertainty exists due to the lack of studies analysing contemporary short stem arthroplasty in osteonecrosis.
Aim The aim of this study was to determine the outcome of the METHA® short stem arthroplasty in patients with progressive osteonecrosis.
Patients and methods This study evaluated the clinical and radiological short- to midterm results after implantation of the cementless short stem arthroplasty METHA®. 73 hips in 64 patients with progessive osteonecrosis after implantation of the METHA® arthroplasty were investigated by measuring the clinical outcome, the Harris Hip Score (HHS) and visual analogue pain scale for the preoperative stage and follow-up. Radiological analyses of X-rays were conducted to assess the bone ingrowth as well as subsidence, osteolysis or fracture.
Results The pain scale improved from preoperatively 7.8 to postoperatively 1.7, while the HHS increased from 41.4 to 90.6 points 34 months post-surgery. Complications associated with revision of the METHA® short stem included two traumatic femoral shaft fracture and one deep infection. The radiological assessment showed good bone ingrowth in all patients despite osteonecrosis.
Conclusion The study confirms encouraging results as well as good bone ingrowth of the cementless short stem arthroplasty METHA® even in patients with osteonecrosis.

Keywords Ostenecrosis of the femoral head · Total hip arthroplasty · Short stem arthroplasty · Metaphyseal anchorage

Introduction

Osteonecrosis of the femoral head (ONFH) is a condition that afflicts young adults and often results in end-stage secondary osteoarthritis of the hip. Pathologic causes include a trauma leading to a dislocation of the hip or a fracture of the femoral neck. A limited blood supply to the femoral head as a result of smoking, excessive alcohol consumption, lipid metabolic disorder or corticosteroid intake can also lead to ONFH. Without treatment, the infraction of the femoral head is likely.

Conflicting reports raised questions about the optimum method to treat patients with ONFH. Early work reported that the standard total hip arthroplasty (THA) for patients with ONFH had sub-optimal results when compared to patients with osteoarthritis [8, 25, 27, 28]. More recent work has refuted these earlier findings and shown that the results of THA after ONFH have an equally good outcome as after osteoarthritis [2, 15, 20, 21]. Reasons for these discrepancies observed in the research literature are manifold. They include the use of first-generation prosthetic designs in the early studies and the fact that underlying risk factors associated with the individual patients were not considered.

The experiments comply with the current laws of Germany.

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There is also uncertainty in the literature about the arthroplasty method that provides the best outcome for patients with progressive ONFH. The different options include hip resurfacing, traditional stem arthroplasties or recently short stem arthroplasties—cemented or uncemented [1, 3, 18, 21–23, 26]. Poor secondary osseointegration of uncemented components made surgeons use cemented components despite studies showing that these cemented components have sub-optimal performance in younger patients. Worries about the poor quality of the femoral bone—for example in ONFH—and possibly persistent defects in bone mineral metabolism resulting in poor osseointegration and thus possibly in loosening of the stems led surgeons to choose traditional stem arthroplasties over short stem arthroplasties or hip resurfacing.

This study was conceived to address both of the above issues by evaluating the outcome of a cementless contemporary short stem THA (METHA®) in patients with ONFH.

Patients and methods

This study reviewed the clinical and radiological outcome after primary short stem THA of the METHA® arthroplasty (B. Braun Aesculap AG, Tuttlingen, Germany) in patients with a preoperative diagnosis of end-stage ONFH according to the ARCO classification. The university's ethical committee approved this study.

Demographics

Between 2005 and 2009 over 500 METHA® short stem arthroplasties were implanted in the Department of Orthopaedic Surgery of the Hannover Medical School due to primary or secondary osteoarthritis.

After obtaining approval from the university's ethical review committee, we evaluated 73 hips of 64 patients with an underlying diagnosis of an ONFH ARCO stage III or IV who underwent a THA with implantation of a cementless short stem hip arthroplasty (METHA®, B.Braun, Tuttlingen, Germany (Fig. 1)). The surgery was conducted between January 2005 and January 2009. A minimum follow-up of 12 months was desired to determine possible complication of secondary osseointegration in the group of patients with ONFH. There were 34 women (37 hips) and 30 men (36 hips) with a mean age of 49.4 years (17.3–67.1 years) at the time of surgery. Nine patients (six men, three women) received a THA bilateral. The possible reasons for the development of the ONFH varied: 13 patients (16 hips) reported of chronical alcohol abuses, three of them had an additional hypercholesterinemia, three patients require regular taking of cortisone after transplantation, eight patients (nine hips) required regular taking of cortisone for other reasons, three patients reported of a previous fracture of the femoral neck, one reported of previous infection of the hip joint, while two other patients had a coagulopathy. The risk factors for the other patients to develop ONFH were unknown. An age above 70 years, a necrotic area reaching above the femoral neck according to a preoperative MRI as well as special anatomic conditions, which made the implantation of this implant impossible, were exclusion criteria for implantation of the METHA® short stem arthroplasty.

Fig. 1 Illustration of the cementless short stem hip arthroplasty (METHA®, B.Braun, Tuttlingen, Germany)

Patients matching the including criteria were asked for a clinical and radiological follow-up. A randomisation of this retrospective study was impossible.

In addition, the Harris Hip Score (HHS) was evaluated for a control group consisting of 59 patients with the underlying diagnosis of primary osteoarthritis (mean age 59.3 years; mean follow-up 30.1 months).

Surgical procedure and implants

All surgeries included the implantation of an acetabular component (threaded or pressfit cups) using standard surgical approaches to the hip (either posterior approach in lateral position or anterolateral or lateral approach in supine position). The short stem arthroplasty METHA® was used as a femoral component. The METHA® arthroplasty is a cementless, collarless and tapered short stem prosthesis. For osseointegration the METHA® arthroplasty is round coated with Plasmapore®, a 20 µm thick μ-Calciumphosphate layer. This layer is supposed to have an osteoconductive effect and accelerates contact between the bone and the prosthesis stem. Depending on age and life expectation of the patient, a polyethylene or ceramic component for the head and inlay were used.

In case of an intraoperative fissure of the metaphyseal part of the femur, which occurred in two of the 73 hips, an osteosynthesis with a K-wire was conducted.

Perioperative protocol

The standard postoperative care of our department for patients after THA was performed for all patients. Preoperatively all patients received a single shot antibiotic therapy. In case of a prolonged duration of the surgery or increased risk of infection, additional antibiotic therapy was prescribed. Thromboembolic prophylaxis included the daily heparin injection as well as compression stockings. Individual adjustment was conducted if necessary. Physical therapy started on the first postoperative day. Immediate full weight-bearing was allowed if no intraoperative fissure occurred. In case of an intraoperative fissure, the patients were limited to 10 kg weight-bearing for six postoperative weeks followed by the successive increase to full-weight-bearing over the next weeks.

Clinical evaluation

The clinical outcome after implantation of the short stem arthroplasty was determined using the HHS and the visual analogue pain scale (VAS). Both scores were recorded at the preoperative stage and at the time of the follow-up. The data were given from each patient. In addition the pre- and postoperative range of motion was documented. Possible complications like loosening, subsidence, fracture, infection or luxation were recorded.

Radiological analysis

In addition to the clinical assessment described in the previous paragraph, the patients were asked for a follow-up X-ray in anteroposterior and axial view. These X-rays were compared to the direct postoperative X-rays in order to determine component positioning, osseointegration and potential loosening or subsidence. To evaluate the possible location of radiolucent lines, the femur was divided into seven zones according to Gruen et al. [13]. Components were characterized as "definitely loose" as soon as a complete radiolucent line or femoral subsidence of 2 mm or more were visible on any X-ray—similar to the criteria described by Mont et al. [23]. Possible bony changes like heterotopic ossification were observed and classified according the Brooker [7].

Statistical analysis

The data were analyzed statistically with the Statistical Package for the Social Sciences (SPSS) software (version 13.0; SPSS, Chicago, IL). A paired sample t test with a p value <0.05 was used for statistically significant values.

Results

Clinical outcome

The HHS showed a significant improvement in function according to the HHS ($p < 0.05$). The mean preoperative HHS of 41.4 points (19–75, SD $\pm$ 15.7) increased to a mean postoperative HHS at an average follow-up of 33.7 months (13–60; SD $\pm$ 10.8) to 90.6 points (39–100, SD $\pm$ 11.6). Thus, there is an increase of the HHS of 49.2 points. The pain according to the VAS (0–10) decreased from preoperatively 7.8 (3–10, SD $\pm$ 1.4) to postoperatively 1.7 (0–6, SD $\pm$ 1.6).

A control group of primary osteoarthritis of the hip including 59 patients showed an increase of the HHS from 43.0 preoperatively to 91.1 points at an average follow-up of 30.1 months. This represents a significant increase of 48.1 points.

There was an improvement in the mean range of motion. The mean range of motion improved from 88.6° to 109.2° in flexion, from 17.0° to 35.1° in abduction, from 13.7° to 24.4° in adduction, from 12.2° to 28.5° in external rotation and from 8.5° to 19.8° in internal rotation.

Radiographic findings

Evaluation of the X-rays at the follow-up compared to the ones during the immediate postoperative revealed in none of the patients a radiolucent line around the femur of more than 2 mm. In one patient a radiolucent line of 1.0 mm was visible restricted to Gruen zone III, IV, V and VII. Signs of a subsidence were visible in one patient with secondary osseointegration (approximately 4 mm of subsidence). In two patients hints of an initial osteolyse were recognized in Gruen zone IV.

Heterotopic ossification was visible in 11 patients (20 %). These ossifications were categorized as Brooker class I in two hips, class II in five hips, class III in two hips and class IV in two hips.

Complications

Complications after THA in patients with ONFH consisted of one deep late infection (1.37 %), one early infection (1.37 %), and two periprosthetic fractures due to a trauma (2.74 %). At the mean follow-up of 34 months, in none of the operated hips signs of loosening or subsidence were visible.

There were only two conversions of the METHA® short stem into one standard stem THA and one revision stem due to traumatic periprosthetic fractures of the femur. One fracture occurred due to a trauma a few days after follow-up and was included in the study as a complication. This

patient fell from a ladder at a height of 2.5 m. The other patients fell on the floor for unknown reason. The patient with the early infection required a revision with lavage and exchange of the inlay and head of the THA. The patient with the deep and late infection necessitated the removal of the entire THA. A new short stem arthroplasty (METHA®) was implanted after the successful treatment of the infection.

Thus, in only 4.1 % of the patients a revision of the METHA® short stem was necessary (survival rate of the METHA® short stem 96 %).

Discussion

The treatment of ONFH remains today a challenging problem in orthopaedics. Ideally, an optimal arthroplasty treatment for progessed ONFH would preserve femoral bone, provide pain relief and allow the patient to resume physical activities [22]. Due to the frequent young age of patients with ONFH, the THA would ideally also preserve bone mass in order to allow for future options as a revision might become necessary when the patients get older.

Common treatments include THA, hemiarthroplasty, total hip resurfacing and short stem THA [1, 3, 18, 21–23, 26]. The number of different treatment options already indicates a lack of a superior procedure in patients with progressive ONFH. By now there are only few studies representing data of the outcome after traditional stem THA [11, 17, 30]. Furthermore, the uncertainty about the best procedure to apply in ONFH is largely caused by the lack of studies with mid- or long-term results of the latest prosthetic designs.

The results of the present study analysing a cementless short stem prosthetic design of the latest generation are encouraging, although only short- to mid-term results and limited numbers of hips were investigated. The present study shows that the short stem arthroplasty METHA®, which is a cementless, collarless and tapered prosthesis stem, did only show one subsidence of few millimetres with secondary bone ingrowth without the need of revision and no loosening in any of the 73 hips studied after a mean follow-up of 34 months. Patients also reported pain relief and significant clinical improvements according to the HHS at this follow-up. There were only two cases (2.7 %) where a replacement of the METHA® short stem arthroplasty was needed caused by a traumatic periprosthetic fracture. The results showed a similar outcome according to the HHS compared to the implantation due to primary coxarthrosis with an even greater increase of the HHS in the group of ONFH.

Opponents of short stem THAs in ONFH argue that a metaphyseal anchorage may be associated an increased risk of subsidence due to poor bone quality within the metaphysis. This poor quality may occur when, in patients with ONFH, the necrotic area exceeds the femoral head. There is histological evidence that ONFH may involve not only the intracapital region but also the femoral neck and metaphyseal area, which may result in a higher rate of aseptic loosening [34]. Tingart et al. analysed the bone matrix composition and trabecular microarchitecture of the femoral metaphysis in patients with ONFH [31]. They concluded that these alterations in bone metabolism and architecture might contribute to the higher rates of stem loosening after total hip replacement in patients with ONFH. However, the results of the 73 hips assessed in the current study indicate that worries about poor secondary bone ingrowth and possible early need of revision of uncemented short stem anthroplasties because of avital necrotic bone material are possibly unfounded. Poor secondary bone ingrowth would have resulted in loosening and subsidence at the mean follow-up of 34 months, since cellular osseointegration is believed to be completed within approximately 12–18 months after implantation. We suspect that the good bone ingrowth is resulting from the removal of avital necrotic bone with the resection of the femoral head. The results also indicate the importance of the proper removal of the avital necrotic bone for the success of the short stem arthroplasty. Furthermore, previous studies revealed good survivorships of uncemented stems even in osteoporotic bone [19, 24]. Nevertheless, we recommend conducting an MRI preoperatively in order to exclude a necrotic area exceeding the femoral neck (Fig. 2a–c).

The good clinical outcome and pain relief reported by patients as well as the survival rate of 96 % in this study of the METHA® short stem arthroplasty are similar to the majority of results reported by other researchers using cementless short stem THAs in ONFH or osteoarthritis. By now there are only few studies presenting data of short stem THA in ONFH. Zeh et al. [34] analyzed the midterm results of the Mayo® short stem THA after ONFH with particular attention on osseointegration. After implantation of 26 Mayo® short stem THAs in 21 patients with ONFH, longitudinal stem migration and varus-valgus femoral stem alignment were examined. The authors determined no increased migration or tilt for Mayo® short stem THA in patients with ONFH. Based on their results they concluded the Mayo® conservative hip as an alternative for operative treatment of patients with ONFH. Karatosun et al. [16] reviewed 19 cementless thrust plate prosthesis in 15 patients with ONFH. The HHS increased from 53 (15–71) to 97 (92–100) points on the final evaluation 12 months postoperatively. Within this first year of follow-up no revision was necessary. Following from this the thrust plate prosthesis was considered to be suited especially for

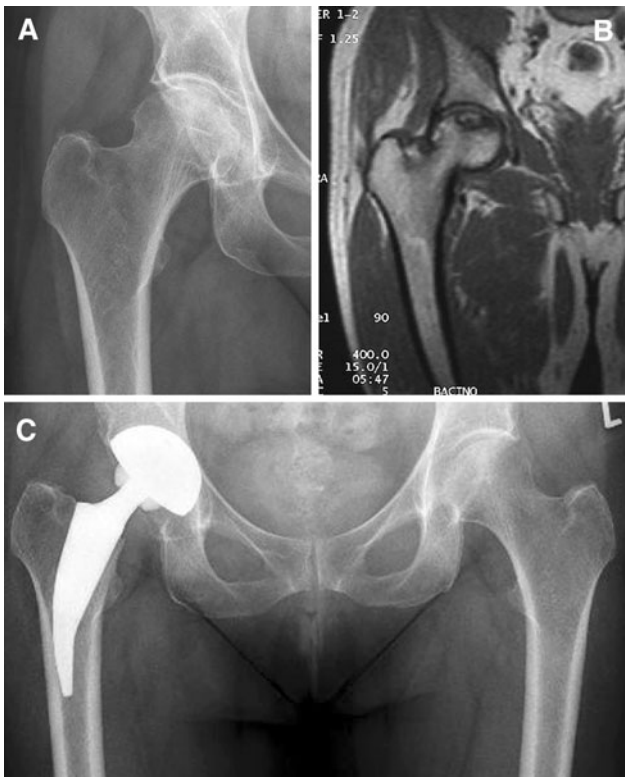

Fig. 2 Preoperative X-ray (**a**) and MRI (**b**) of the hip joint in a patient with ONFH limited to the femoral head. **c** Postoperative X-ray of the hip after implantation of the short stem THA METHA®

patients with ONFH. Similar results were presented by Yasunaga et al. analysing 31 thrust plate prosthesis in 27 patients with ONFH [33]. Mechanical loosening developed about 1 year postoperatively in one THA with a bone defect. Grade 1 stress shielding was observed in four joints. Nevertheless, they outlined the thrust plate prosthesis representing an outstanding prosthesis for young patients with ONFH in terms of bone preservation and physiological load transfer. Inferior results were presented by Fink et al. analyzing the outcome of 72 thrust plate prosthesis in 63 patients with ONFH [10]. The HHS increased continuously from 50.0 points beyond 79.8 points after 3 months, to 86.8 points within the first year, and subsequently remained stable at this level. Revision was necessary in six cases (8.3 %). Of these, three had an aseptic loosening of the implant. The authors concluded from their data that ONFH following renal transplantation and extension of the necrotic area into the femoral neck are contraindications for the implantation of the thrust plate prosthesis. Furthermore, it is questionable whether the results of the thrust plate prosthesis can be transferred to other short stem THAs because of a different fixation concept. Publication of other short stem THAs is rare or even missing [9]. Drescher et al. mentioned that short stem THA may represent an improvement for young patients due to the bone preserving technique and based on his own experience to revise the METHA short stem in case of loosening to a standard stem. Wang et al. reported of results of the CPF as a femoral neck preserving THA in nine hips due to ONFH [32]. The mean HHS improved from preoperatively 42.8 to postoperatively 92.8 after 18.1 months. No signs of loosening or osteolysis were visible.

In addition, the current study confirms the clinical outcome of the METHA® of the few other existing studies, which not only assessed the THA in patients with ONFH. Braun and Sabah reported of a HHS of 95 points in a group of 48 patients at a follow-up of 2.4 years after implantation of the METHA® short stem arthroplasty due to primary or secondary coxarthrosis [6]. They performed one revision due to periprosthetic fracture and one due to breakage of the cone adapter. In one patient radiological assessment showed an aseptic loosening. Braun and Sabah also recognized in seven patients a subsidence of 2 mm with secondary osseointegration. Furthermore, a review on short stem arthroplasties including the METHA® also revealed encouraging short term results [14]. In addition, Schmidutz et al. [29] evaluated even the ability to conduct sports activities after implantation of the METHA® short stem THA. They concluded that patients with a short stem hip implant can return to a good level of activity postoperatively. Participation in sports almost reached similar levels as preoperatively but with a shift from high- to low-impact activities.

However, the results of the current study are not only comparable with studies analysing short stem THA in patients with ONFH or primary coxarthrosis, but also with studies analysing the group of ONFH using other types of THA than short stem THA. Garino et al. [12] presented a 96 % survival rate 55 months postoperatively after reviewing the outcome of 123 cemented and hybrid THAs in patients with ONFH. Kim et al. [18] stated a survival rate of 98 % after a followup of 122 months in 100 patients with ONFH after implantation using either a third-generation cementing or a second generation cementless technique. Thus, with regard to the presented literature and the data of the current study it can be supposed that contemporary cementless, short stem arthroplasties such as the METHA® offer similar performance as traditional stem arthroplasties, while allowing for future revision using a traditional stem arthroplasty in case of a femoral failure.

However, not just the design of the stem is important for a good clinical outcome. The biomechanics of the hip is more complex than often expected. An understanding of hip joint biomechanics constitutes an important background for the diagnosis and treatment of hip disorders [5]. This includes knowledge of the kinematics, loading experienced during static and dynamic activities, the transmission of mechanical stresses between the articulating

members of the joint, and the interplay between the various tissues and structures comprising the hip. These different facts have to be considered when implanting THA and analysing persistence of hips pain because there are many factors that can result in hip pain [4]—for patients with and without THA.

The limitations of this study are the restriction to mid-term results and the limited number of hips investigated. However, the followup is long enough to gain information about the osseointegration of the cementless short stem THA, which can be feared as crucial due to the supposed poor bone quality in case of ONFH and the decreased surface of the short stem arthroplasty compared to traditional stem arthroplasty resulting in a decreased primary stability. Future work should incorporate long-term results from the arthroplasty of cementless, short stem arthroplasties, and the analysis of a larger number of cases.

As far as a conclusion can be drawn from the results, the study confirms the advantages of the short stem arthroplasty METHA®: the preservation of the bone of the proximal femur, good options in case of necessary revision as well as a cementless fixation including a good secondary bone ingrowth even in patients with ONFH. Further inverstigations are necessary to present mid- to long-term results after contemporary short stem THA.

Conflict of interest Three of the authors (Floerkemeier T, Windhagen H and von Lewinski G) are paid instructors for the company B.Braun Aesculap, Tuttlingen.

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