Author's response to reviews

Title: Hemiarthroplasties in young patients with osteonecrosis or a tumour of the proximal femur; an observational cohort study

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Abstract

Background
The failure scenario of total hip arthroplasty (THA) in younger patients (< 65 years) is dependent upon the fixation and wear of the acetabular component. In select cases, where endoprosthetic replacement of the femoral head is unavoidable for limb salvage or functional recovery, hemiarthroplasty is a viable alternative. The purpose of this study was to evaluate hemiarthroplasty as a treatment strategy for young patients with osteonecrosis or a tumour of the proximal femur.

Methods
Between 1985 and 2008, 42 hemiarthroplasties (unipolar and bipolar) were performed in patients younger than 65 years. Patients had a diagnosis of osteonecrosis (n=13) or a tumour of the proximal femur (n=29). All patients were evaluated at yearly follow-up examinations. Revision or conversion to a THA was regarded as a failure of the implant. Kaplan–Meier analysis of implant survival was conducted. To determine significant differences between categorical groups, the Pearson chi-square test was used. In numerical groups the independent t-test and one-way ANOVA were used.

Results
After a mean follow-up of 7.1 years, failure of the hemiarthroplasty occurred 6 times. The Kaplan–Meier survival analysis with conversion to THA or revision as an endpoint for the bipolar hemiarthroplasties (n=38) showed a 96% survival rate at 15 years and a 60% survival rate at 20 years. In the unipolar type (n=4) we found a conversion rate of 50% within 3 years.

Conclusions
Bipolar hemiarthroplasty is a reasonable alternative to THA in a young patient with osteonecrosis or a tumour of the proximal femur. Because of the high conversion rate after unipolar hemiarthroplasties, we would not recommend this type of prosthesis for the younger patient.

Keywords: bipolar, hemiarthroplasty, osteonecrosis, total hip arthroplasty, tumour, unipolar, young patients,
Background

Total hip arthroplasty (THA) is one of the most important advances in lower extremity reconstruction of the past century. However, this procedure is known to fail more frequently in younger patients than in older patients [1-5]. One hypothesis for the higher failure rate in young patients is that the high activity level of these patients increases the risk of wear, debris reaction and mechanical failure of the implant [6]. This is seen especially in acetabular component loosening [7-11]. Because revision of the implant becomes more likely with higher functional demand, hemiarthroplasty may be a viable option for younger patients. Unipolar or bipolar hemiarthroplasty is used almost exclusively for proximal femoral fractures in the elderly patient [12-20]. Acetabular protrusion is judged to be an important factor causing early failure or problems at revision [6,21-24]. Literature of this procedure in young patients is scarce; however, better bone stock might prevent protrusion or acetabular erosion in this population.

End-stage osteonecrosis and oncologic destruction of the proximal femur are similar in that both can be treated by an endoprosthesis. At our medical centre, both diagnoses are valid indications of hemiarthroplasty in the young patient. Although randomised controlled trials (RCTs) show superior results for THA compared to hemiarthroplasties in the short-term and tend to be superior after 7–10 years of follow-up, these studies only investigated fractures in elderly patients with a mean age of >70 years [13-15,25,26]. In this study we reviewed all consecutive hemiarthroplasties in young patients from our medical centre, both unipolar and bipolar, as indicated by osteonecrosis or tumour resection. The aim of this study was to evaluate hemiarthroplasty as a valid treatment strategy for young patients with osteonecrosis or a tumour of the proximal femur.

Patients & Methods

This study comprised an observational cohort study of patients who underwent a hemiarthroplasty, either bipolar (n=38) or unipolar (n=4), with osteonecrosis of the femoral head (n=13) or a proximal femur resection for a tumour (n=29). The medical records and radiographs of patients seen at the Leiden University Medical Centre between 1985 and 2008 were reviewed. Radiographic evaluation for acetabular erosion was classified
according to Baker et al. [14].

Revision or conversion to a THA was regarded as a failure of the implant. Kaplan–Meier survival analysis was performed for both unipolar and bipolar arthroplasties, with conversion to THA or revision as the endpoint. A COX regression analysis was used to determine the independent effects of variables. To determine a significant difference between categorical groups, the Pearson chi-square test was used. In numerical groups the independent t-test and one-way ANOVA were used. An alpha value of 0.05 was used as the level of significance. All statistical analyses were performed using SPSS version 17.0 for Windows (SPSS Inc., Chicago, IL). Study approval by an ethics committee is not necessary for observational research in the Netherlands.

Results

From 1985 to 2008, 42 hemiarthroplasties were performed in 39 patients with osteonecrosis grade IV or a tumour in the proximal femur. Sex, side and diagnosis are shown in Table 1. The average age at the time of operation was 39 years (SD=15, range 13–66 years). All patients were operated on at the Leiden University Medical Centre, by orthopaedic surgeons with experience in endoprosthetic reconstruction of the hip. The mean follow-up time was 7.1 years (SD=6, range 1–25 years). Fifteen patients (15 implants) died, 14 from the sequelae of their primary tumour, during the follow-up period: 1 in the unipolar group and 14 in the bipolar group. Among the deceased patients, none had a revision or conversion before the time of death. This did not differ significantly between the unipolar and the bipolar group (p=0.427).

Among our patients, osteonecrosis caused by high-dose corticosteroid use was seen in five patients (eight implants), in one case by alcohol abuse, in two cases by an earlier operation or trauma of the ipsilateral limb and in two cases a cause could not be determined. Corticosteroid therapy was started as part of treatment in each case of leukaemia; all patients had a grade IV osteonecrosis, according to Steinberg’s classification [27]. Tumours were malignant in 24 cases and benign in 2 cases; in the remaining 3 cases a metastasis of breast cancer in the proximal femur was the indication for resection. Ten cases, including the three metastases of breast cancer, had a metastasis in follow-up or at presentation (Table 2).
Each respective type of prosthesis used was the preferred choice at the time of implantation (Table 3). Because a significant difference in prosthetic survival occurred between the unipolar and bipolar hemiarthroplasties, we considered them to be two separate groups. Of the 42 femoral stems, 1 (a bipolar implant) was revised because of a pseudo-arthritis of the allograft femoral junction, and was converted to a THA after 4 years. No acetabular erosion was noted. Two bipolar implants were converted to a THA after 7.5 and 23.7 years and one bipolar head was exchanged after a mechanical failure of the locking ring of the bipolar head after 15.1 years. In the two patients with bipolar hemiarthroplasties converted to a THA, acetabular erosion was objectified during operation (Table 4).

In the unipolar group, two conversions to THA were performed because of pain in the groin region, after a positive reaction on bupivacaine. Both patients had evidence of acetabular erosion during surgery (Table 4, Table 5). Apart from the higher failure rate in unipolar implants, they also failed faster, with a mean survival of only one year. Table 5 lists the specific cases of implant failure. Due to the small amount of unipolar prostheses in this series, a Kaplan–Meier survival plot of this group alone was not useful. When we combined the uni- and bipolar prostheses groups, a Kaplan–Meier plot showed a survival rate of 89% after 15 and 56% after 20 years (Figure 1). The Kaplan–Meier analysis for the bipolar prostheses alone showed a survival rate of 96% after 15 years, and after 20 years this was reduced to 60% (Figure 2). The unipolar prostheses had a survival rate of only 50% after nearly 2 years. A COX regression analysis showed no statistically significant difference in side operated, treatment indication, sex, bipolar or unipolar hemiarthroplasty or technique used (cemented or uncemented). There was no significant difference in the specific type or brand of prostheses used and failure of the implant.

Other complications requiring a second surgery, but not revision of the implant, included: two infections treated with debridement and antibiotics (systemically and locally) and two dislocations, including one of the patients with an infection. Both dislocations were treated by a closed reduction and patients were stable afterwards. Radiographic evaluation showed acetabular erosion in 15 implants. Of these, 13 were grade I (narrowing of articular cartilage, no bone erosion) and only 2 were a grade II (acetabular bone erosion and early migration); protrusio acetabuli (grade III) was not seen (Table 5).
Discussion

Total hip arthroplasty versus hemiarthroplasty

Total hip arthroplasty in the elderly is a safe and effective procedure, with implant survival rates as high as 90 and 75%, after 15 and 25 years, respectively [1]. Whereas the majority of older patients are treated with a THA because of primary osteoarthritis, the indications for an arthroplasty in young patients vary and include secondary osteoarthritis (most commonly secondary to developmental dysplasia of the hip or trauma), osteonecrosis, ankylosing spondylitis, juvenile idiopathic arthritis, epiphyseal dysplasia, sequelae of Perthes disease, chondrodystrophy and fractures. Although RCTs show superior results for THA compared with hemiarthroplasties in the short term and tend to be superior after 7–10 years of follow-up, these studies have focused solely on fractures in elderly patients with a mean age of >70 years [13-15,25,26].

Young patients (under 50 years) have a much higher risk of implant failure for a THA, especially for the acetabular component [1-5]. Several studies report the revision rate after a THA due to aseptic loosening of the acetabular component as between 20 and 63% after 10–22 years [7-11]. The revision rate for femoral stem loosening, however, was 0–23% after 10–22 years. Publications from the same authors report an improved 10-year survival rate of 88%, with impaction bone grafting when an acetabular defect is combined with cemented cups [5,28,29].

As the femoral component is less likely to fail in young patients, this suggests that endoprosthetic survival in younger patients is improved with hemiarthroplasties. The reported revision rate of bipolar hemiarthroplasties in young patients is 7–21% after 6–14 years [24,30,31]. This concurs with our study population, in which the femoral component had to be revised in one case because of pseudo-arthrosis at the femoral allograft junction. Dislocation is a serious complication more often seen after THA as compared with hemiarthroplasty, especially in the elderly group after a femoral neck fracture [32]. In our study population, three arthroplasties dislocated.

Our results indicate that a bipolar hemiarthroplasty, with 96% survival rate after 15 and 60% survival rate after 20 years regardless of age or underlying disease, is superior to a THA in young patients. In the unipolar group, however, the survival rate was only 50% after 2 years. One of the major failure mechanisms after hemiarthroplasty is protrusion of the metal head as the acetabular articular cartilage
degenerates [6,21-24]. In rare cases, osteolysis of the acetabulum may be seen [33]. The degeneration of the articular cartilage is believed to be mostly influenced by activity level [6]. The histological process of this degeneration begins with abnormal stress to the articular cartilage due to the hard bipolar cup. This facilitates the secretion of degenerative enzymes, which induces the loss of initial glycosaminoglycan. The articular cartilage then softens and loses elasticity. Collagen fibres are destroyed and the surface integrity changes. This process is correlated with activity levels, i.e., repetitive stress, and the duration of articulation of the implant with the acetabulum [6]. Eventually the head will migrate through the acetabular cartilage, leading to the failure of the (bipolar) hemiarthroplasty.

Several studies regarding the improvement in functional status after a conversion to a THA following a failed hemiarthroplasty report excellent results [34-36]. When these conversions to a THA were followed over time, they showed a better survival rate of the acetabular component as compared with the femoral component [34,37]. One author reported a reoperation rate of only 4.5% for aseptic loosening of the acetabular component after 10 years [35]. We postulate that these results can be explained by the repetitive stress caused by the hard bipolar head. This stress not only causes degeneration of articular cartilage, but also causes the subchondral bone to harden. This process, well known in osteoarthritis, might make the acetabulum component less vulnerable to loosening when conversion to a THA is necessary [38,39]. In young and active patients, as in our study population, the acetabulum is almost always without damage. Subsequently, the subchondral bone should be softer than in patients who have suffered abnormal stress levels, and we hypothesize this might be the cause of the high rate of aseptic loosening of the acetabulum in THAs in young patients. We could not confirm this in the current literature and further study should be conducted to explore this hypothesis. In our study population we did not encounter problems of protruding bipolar heads.

Hemiarthroplasties produce abnormal stress levels on the acetabulum, which in turn leads to degeneration [21,40]. However, whether this degeneration leads to pain, complications, or implant failure differs from patient to patient. Extensive follow-up, both clinical and radiological, is advised. Two previous studies have reported on the clinical outcome after bipolar hemiarthroplasties [23,36]. In both studies, a correlation was shown between a lower Harris Hip Score and articular degeneration. Furthermore, the incidence of buttock, groin or thigh pain could be used as a marker for failure of the implant. Groin or buttock pain was reported for
articular degeneration, whereas thigh pain was believed to be a symptom of loosening of the femoral component or an impending fracture. Both studies suggest early revision or conversion in patients with any of these symptoms [23,36]. The patients in our study population with a failed implant reported similar complaints of pain (Table 5).

Unipolar versus bipolar hemiarthroplasty

Bipolar hemiarthroplasties articulate at two different levels, and this dual bearing is thought to lead to less acetabular wear. Another advantage of this design is increased range of motion compared to unipolar implants [18]. A potential disadvantage of the bipolar implants is the risk of polyethylene wear, which can cause synovitis and loosening of the stem. RCTs have failed to present convincing data on differences in clinical outcome between unipolar or bipolar designs, and a Cochrane review in 2010 concluded there is currently not enough evidence to support the use of either unipolar or bipolar prosthesis when performing hemiarthroplasty [12]. Acetabular erosion is thought to be the primary factor influencing clinical outcome and the reason for revision or conversion. Studies of acetabular erosion in patients with hemiarthroplasties show incidences of 2–36% for unipolar implants, and 0–26% for bipolar implants [13,14,18,22,41,42]. Baker et al. [14] introduced a grading system for acetabular erosion and reported 66% erosion, mostly grade I, after only 3 years of follow-up. A recent study found a much lower percentage in bipolar hemiarthroplasties, with only 14% of patients showing acetabular erosion (all grade I) after four years of follow-up [13]. The same authors performed a RCT, which found equivalent clinical outcomes between unipolar and bipolar hemiarthroplasties, but a significantly higher incidence of acetabular erosion in the unipolar group [16]. Again, it should be mentioned that these studies are based on elderly patients. In our study we saw acetabular erosion in 35.7% of patients, mostly grade I, after a mean follow-up of 7.1 years, which is longer than the studies mentioned above. Because of the small number of unipolar hemiarthroplasties performed in our study, we could not analyse differences between the two types of hemiarthroplasties.

Limitations

This study had several limitations. First, the number of patients was small, especially in the unipolar hemiarthroplasty group. Secondly, it comprises a heterogeneous group of patients. However, the acetabulum was not affected in either patient group (osteonecrosis and tumour), an important difference with other indications for hip arthroplasty. Also, the tumour population can create a bias because of lower life expectancy.
after surgery.

Conclusions

Young patients requiring a hip arthroplasty for treatment of a tumour or severe osteonecrosis of the femoral head are a very specific patient group, of which little is known regarding the preferred treatment. Bipolar hemiarthroplasties are a reasonable option for this specific patient group with a survival rate of 96% after 15 years and 60% after 20 years, with conversion to THA or revision as an endpoint. The advantage of 15 or more years before converting to a total hip, in our view, outweighs the early loosening of an acetabular component. Furthermore, conversion to a THA is not difficult, with the hardened subchondral bone of the acetabulum a possible positive factor influencing longer acetabular component survival after conversion. Because of the high conversion rate after unipolar hemiarthroplasties in our study population, we would not recommend this type of prosthesis for this particular patient group.