The concern of extensive fracturing and bone damage during implant removal has been reported for ingrowing stems, in particular in extended porous coated stems, potentially impeding successful re-implantation of a femoral revision implant and consequently debilitating patients for life. The aim of the present study is to describe this particular complication and comparing the occurrence in porous coated and hydroxyapatite (HA) coated femoral implants.

62 consecutive revision hip replacements were performed between January 2010 and December 2016 at a single academic institution. Only revisions of a primary total hip replacement were included. All surgeries were performed by the same senior surgeon. Clinical follow-up involved examination with the Harris hip score (HHS) at 2 years post surgical intervention. Fracture occurrence and severity were compared between groups by means of the Vancouver classification for intraoperative fractures. Overall, significant higher rates of fracturing were observed in the porous coated group (81.8%, p<0.05) compared to the HA coated group (43.5%, p<0.05). Of these fractures, the majority (72.7%) were B3 fractures. There was a significant difference between the mean HHS in the porous-coated group versus the group with HA coating (mean Harris Hip Scores of 68.45 vs 86.17, p = .004).

Surgeons have to be wary with implanting porous coated stems in primary hip arthroplasty, especially in younger patients who have a high likelihood of future revision surgery, due to the catastrophic peri-operative fractures associated with the removal of these stems.

**Keywords** : Hydroxyapatite coating ; porous coated ; fracture risk ; revision surgery ; hip replacement ; Harris hip score.

**INTRODUCTION**

Primary hip arthroplasty is likely the most successful and cost-efficient procedure in orthopedic surgery. Patients and surgeons can expect a hip replacement to last 25 years in around 58% of patients according to National joint registries (1). With changing patient demographics, increasing life expectancy and active lifestyle at older ages, the future demand for joint replacement surgery is expected to increase by 175% by 2030 in the USA, parallel in the UK and Wales and in the Netherlands by 53 percent during the same period (2-4). A similar growth in revision surgery procedures, the outcome of which is often less favorable can therefore be expected (4-6).
Revision surgery is generally more expensive, provides a lesser clinical prognosis and can further decrease quality of life and activity (4). Furthermore, revision hip replacements fail much earlier than do primaries, necessitating further revisions (1). Although the outcome of primary surgery is well documented, revision surgery is far less popular in terms of survival and outcome studies (6,7-8). A particular concern that has been raised over the last two decades is the complicated removal of cementless stems, potentially impeding successful re-implantation of a femoral revision implant and consequently debilitating patients for life (9-12). Despite the massive impact on patients’ quality of life and related social costs, given these complications, there is almost no literature available describing its prevalence or risk factors.

The concern of extensive fracturing and bone damage during implant removal has been reported for ingrowing stems. In particular for extended porous coated stems, where these stems seems so firmly osseointegrated that it can be a challenge extracting the implant without fracturing of the calcar and trochanters or causing severe perforation of meta- and diaphysis (12,13). The aim of the present study is to describe this specific complication and to compare the occurrence in hydroxyapatite (HA) coated and porous coated femoral implants.

**MATERIAL AND METHODS**

62 consecutive revision hip replacements were performed between January 2010 and December 2016 at a single academic institution. Only revisions of a primary total hip replacement were included all done by the same surgeon. All revision surgery was performed through a posterolateral approach. Exclusion criteria were revisions of already revised total hip replacement, periprosthetic fractures and loosening of the femoral stem.

Permission was obtained from the university and hospital internal review boards prior to the commencement of the study. All patients gave informed consent to participate in the study.

The patient’s medical record was reviewed to identify the side of the operation, the type of primary stem, the date of primary hip procedure, the type of revision performed (use of primary stem, revision stem, girdlestone or spacer). The preoperative radiographs of all hips were assessed to determine the femoral bone type with use of the isthmus ratio described by Dorr (14).

Fractures were identified by a retrospective review of the operative record and verified by examination of the postoperative radiographs by consensus of 2 clinical experts. All immediate postoperative radiographs (standard anteroposterior pelvis and anteroposterior and lateral hip x-rays) were reviewed to characterize the presence and type of intraoperative fracture. The validated Vancouver system for classifying postoperative periprosthetic fractures was adapted for use in the intraoperative period and was used to classify the intraoperative fractures. Although, in contrast to the Vancouver classification system for postoperative fractures, its reliability and validity for perioperative fractures have not been tested (15).

Despite the fact that it was invented for the description of fractures that originate in the placement of primary prostheses, the classification is valuable in describing fractures that arise during extraction of the femoral component.

According to this classification system, the femur was divided into three anatomical areas: A (the pertrochanteric region), B (the diaphysis), and C (the distal metaphyseal, or supracondylar, region). In each anatomic location, the fracture was categorized as 1 (a cortical perforation), 2 (an undisplaced linear crack), or 3 (a displaced or unstable fracture).

Clinical follow-up involved examination with Harris hip score at 2 years post surgical intervention.

**Statistical analysis**

Statistical analysis was conducted by using SPSS Statistics 23 software. Significance level was established at P ≤ 0.05. Fracture occurrence and severity were compared between groups by means of the Pearson Chi-square Test.

**RESULTS**

34 patients were included in the cohort. 11 in the non-cemented porous coated group and 23
in the hydroxyapatite group. The porous coated group consisted of 10 females and one male. In the hydroxyapatite group we encountered 12 females and 11 males (Fig. 1.). The mean age of the cohort at the time of the procedure was 63 years. The mean age in the hydroxyapatite group was 64 years and the mean age in the porous coated group was 59 years. There was no significant difference between the mean age of the groups (p=0.331). (Table 1)

2 patients were lost to follow up because they did not want to participate in this study. 1 patient had deceased due to pulmonary complications arising after surgery.

Indications for revision surgery were aseptic loosening, metallosis, infection, wear/osteolysis, luxation and chronic pain.

Overall, higher rates of fracturing were observed in the porous coated group (81.8%, p < 0.05) compared to the HA coated group (43.5%). Of these fractures, the majority were B3 fractures, 72.7% of the patients in the porous coated group suffered from a B3 fracture. Only 18.2% of the patients had no fractures after removal of the femoral stem. A detailed overview of the findings is presented in table 2.

The mean HHS at 2 years was 80.44 (34-100). The HHS in the porous coated group (68.45) was significantly lower compared to the HHS in the HA group.

Table 1. — Demographic Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Porous coated</th>
<th>Hydroxyapatite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at 2 years follow up (SD) (P = 0.331)</td>
<td>59.27 (13.108)</td>
<td>64.09 (13.389)</td>
</tr>
<tr>
<td>Sex M/F</td>
<td>1/10 (9.1%/90.9%)</td>
<td>11/12 (47.8%/52.2%)</td>
</tr>
<tr>
<td>Dorr A/B/C</td>
<td>5/6/0 (45.5%/54.5%/0%)</td>
<td>11/12/0 (47.8%/52.2%/0%)</td>
</tr>
<tr>
<td>Mean HHS (SD) (P = 0.004)</td>
<td>68.45 (14.067)</td>
<td>86.17 (15.882)</td>
</tr>
</tbody>
</table>

Table 2. — Fracture occurrence and severity by means of between the porous-coated and HA coated group the Vancouver classification for intraoperative fractures

<table>
<thead>
<tr>
<th></th>
<th>No Fracture</th>
<th>Fracture</th>
<th>A1</th>
<th>A2</th>
<th>B1</th>
<th>B3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porous Coated (%)</td>
<td>2 (18.2%)</td>
<td>9 (81.8%)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>HA coated (%)</td>
<td>13 (56.5%)</td>
<td>10 (43.5%)</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

(p<0.05)
unstable fractures of the per trochanteric region extending to the diaphysis (e.g. figure 1). This type of fractures can compromise future surgical options, since they can oblige the use of long revision stems and sometimes leave no other option than a definitive girdlestone. In our study this resulted in significantly worse clinical outcomes after 2 years in the porous-coated group versus the HA coated group (mean Harris Hip Scores of 68.45 vs 86.17).

It is challenging removing osseointegrated cementless porous-coated stems due to the very irregular surface that stimulates bony ingrowth in gaps. We have the impression that it is difficult to find a proper resection plane between the implant and the femur. A thin osteotome cannot reach the osseointegrated portion distal to the metaphysis of the femur, making extraction of the stem extremely difficult. A femoral osteotomy could not overcome this problem.

In contrast, hydroxyapatite implants allow a faster closure of the gaps between stem and bone. These stems can stimulate bone ingrowth early, and after this ingrowth the coating is resorbed (20). Which results in a fixation on a relatively smoother stem surface, and subsequentially easier stem removal in case of revision surgery.

Cementless fixation in primary hip arthroplasty is associated with progressive stress shielding (21). An insufficient load transfer between bone and implant can be influenced by the difference in coating on a hip implant. There is evidence that suggest that HA-coated stems have significantly less stress shielding and superior osseous remodeling (22). We assume that this might influence the lower prevalence of perioperative fractures in the removal HA coated stems.

Limitations in our study are the small cohort and the uneven distribution of males/females in the different groups.

Further studies are needed to confirm this hypothesis. If confirmed, we should rethink the usage of these implants in primary fixation, especially in young people who may need to undergo revision surgery.
CONCLUSION

Surgeons have to be cautious with implanting porous coated stems in primary hip arthroplasty because of the high occurrence of perioperative fractures when removing these femoral implants during revision surgery. The clinical results of these perioperative complications are devastating. Therefore, we believe that the implantation of porous coated stems in younger patients should be carefully considered.

REFERENCES

1. JT Evans, JP Evans, RW Walker, AW Blom et al. How long does a hip replacement last? A systematic review and meta-analysis of case series and national registry reports with more than 15 years of follow. The Lancet. 2019