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ORIGINAL STUDY

Fracture risk during extraction of well-fixed extended cementless stems : porous versus hydroxyapatite coated

Frederik Matthys, Jan Van Meirhaeghe, Christophe Pattyn

From the University Hospital of Ghent, Belgium

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)*.

■ Frederik Matthys, MD
■ Jan Van Meirhaeghe, MD
■ Christophe Pattyn, MD, PHD
Department of Orthopaedic Surgery, Ghent University Hospital, Belgium
Correspondence : Frederik Matthys, Franklin Rooseveltlaan 134, 9000 Gent, Belgium. Phone : 0032 496 340436.
Email : frederik_matthys@hotmail.com

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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 $P \leq 0.05$. 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

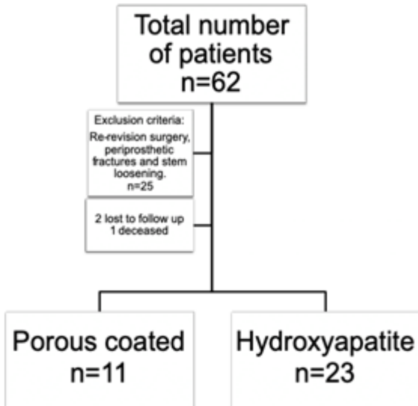

Fig. 1. — Flowchart

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.

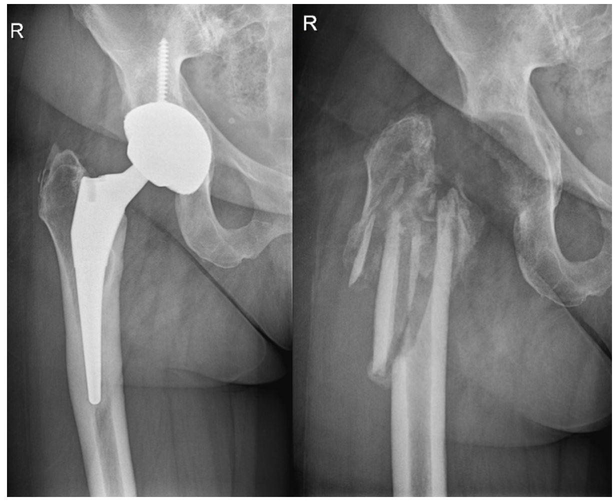

Fig. 2. — Extensive damage to the proximal femur after removal of a porous coated femoral implant.

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

Table 1. — Demographic Characteristics

	Porous coated	Hydroxyapatite
Mean age at 2 years follow up (SD) (P = 0.331)	59.27 (13.108)	64.09 (13.389)
Sex M/F	1/10 (9.1%/90.9%)	11/12 (47.8%/52.2%)
Dorr A/B/C	5/6/0 (45.5%/54.5%/0%)	11/12/0 (47.8%/52.2%/0%)
Mean HHS (SD) (P = 0.004)	68.45 (14.067)	86,17 (15.882)

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

	No Fracture	Fracture	A1	A2	B1	B3
Porous Coated (%)	2 (18,2%)	9 (81,8%)	0 (0%)	1 (9,1%)	0 (0%)	8 (72,7%)
HA coated (%)	13 (56,5%)	10 (43,5%)	4 (17,4%)	2 (8,7%)	2 (8,7%)	2 (8,7%)

(p<0.05)

Table 3. — Hip score (HHS) at 2 years post surgical intervention between the porous-coated and HA coated group.

	Mean HHS (SD)
Porous coated	68,45 (14,067)
HA coated	86,17 (15,882)
Total	80,44 (17,289)

(p=0.004)

coated group (86.17). This was a significant result (p = .004). (Table 3)

DISCUSSION

The etiology of intraoperative fractures associated with cementless fixation in primary hip arthroplasty has been well documented *(16)*. These include several intrinsic and extrinsic factors like poor bone stock, the use of a straight stem and underreaming. These fractures are associated with increased morbidity and mortality, blood loss and a poor long term clinical function.

However, there is little literature available describing the prevalence and the risk factors of intraoperative femoral fractures in revision hip arthroplasty. This study is the first article comparing the risk of intraoperative femoral fractures in revision surgery between HA coated and porous coated femoral implants.

In the late 1980s, hydroxyapatite was applied on the implant surface in uncemented total hip arthroplasty because of its biocompatibility and osteoconductive potential *(17)*. Some studies have shown that the use of HA coating on porous-coated stems improved clinical and radiographic outcomes compared to porous coated stems. It has been mentioned that HA coating improves the postoperative Harris Hip Score (HHS), reduce the incidence of thigh pain and reduce the incidence of femoral osteolysis *(18)*. Other articles have demonstrated no clinical or radiographic advantages with use of HA coating *(19)*.

We observed that the fracture risk of stem removal is highly influenced by the type of coating. Overall, the intraoperative fracture risk was double as high in porous-coated stems compared to HA coated (81.8% vs 43.5%). Of these fractures, the majority (72.7%) were B3 fractures which are unstable fractures of the pertrochanteric 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.

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