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Long-Term Outcome of a Metal-on-Polyethylene Cementless Hip Resurfacing

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ABSTRACT

Due to the well-documented problems surrounding metal-on-metal bearings, the use of hip resurfacing has declined. Since the potential benefits of hip resurfacing remain desirable, it may be beneficial to investigate the long-term outcome of hip resurfacings using metal-on-polyethylene in the 1980's. We report the long-term survivorship and modes of failure of a cementless metal-on-polyethylene resurfacing (n = 178) with different porous ingrowth surfaces. While acetabular loosening was absent, a high incidence of femoral failures (femoral loosening = 18.1%, osteolytic neck fracture = 21%) occurred despite using the same ingrowth surface for both components. Ongoing developments using the lessons learned from these previous generation components and utilizing modern low wear materials, e.g., cross-linked polyethylene, may lead to improved implants for future hip resurfacings.

Hip resurfacing was developed for the benefits of stability, preservation of biomechanics, leg length equality, bone conservation and potential ease of revision to total hip arthroplasty (THA) [1,2]. Initial designs of hip resurfacing fixed with polymethylmethacrylate (PMMA) were associated with high rates of aseptic loosening and osteolysis, due primarily to polyethylene wear-related issues [3,4]. Although there were initial success and promise of a satisfactory time-buying procedure prior to THA, ultimately, the less than optimal outcome of these early metal-on-polyethylene designs diminished the enthusiasm of the community and the procedure was largely abandoned. The rationale for the present study's cementless design was to increase durability, similar to cementless designs that were introduced for total hip arthroplasty. This resurfacing cementless design used a two-part socket resulting in significant improvement in socket fixation and durability. However, wear-related reaction to polyethylene ultimately proved to be a major problem. Eventually, modern metal-on-metal bearing surfaces were developed to eliminate polyethylene wear debris issues and reduce volumetric wear [1,3–5]. While overall outcomes greatly improved compared to previous resurfacing designs, wear-related problems in some designs led to an unsatisfactory incidence of adverse localized tissue reactions (ALTR), defined as metal sensitivity, osteolysis, or formation of a mass. Today, ALTR is frequently attributed to metal-on-metal bearings due to lack of ball coverage [6–8].

Due to the well-documented controversies surrounding metal-on-metal bearings, especially when very large resurfacing sockets were used to accommodate large femoral heads, the use of resurfacing has declined [9,10]. Since the intended benefits of hip resurfacing remain desirable, efforts to redesign hip resurfacings are underway to take advantage of cementless fixation and newer, more wear resistant polyethylene (crosslinking and improved sterilization techniques) [11–13]. It may be beneficial to investigate an early cementless resurfacing design using polyethylene for lessons, their reasons for failure and beneficial attributes that can be applied to these future designs.

In this manuscript, we report the long-term survivorship and modes of failure of two first generation cementless metal-on-polyethylene resurfacing design, the porous surface replacement (PSR, Zimmer, Warsaw, IN; DePuy, Warsaw, IN).

Methods and Materials

Patient Design

Between 1983 and 1992, a total of 223 porous coated hip resurfacings (197 patients) were performed by the senior author. Of these, only cases utilizing both an uncemented femoral and acetabular component, 178 hip resurfacings (163 patients), were included in this study. Hybrid resurfacings with cemented femoral components were excluded. Patients were selected based on their desired activity level, age, and likelihood of subsequent revision during their lifetime. The mean age at time of surgery was 51.7 years (range 15–79 years, median 54.1 years) with males making up 64% of the patients (n = 113). The indications for index surgery included osteoarthritis (53%) and osteonecrosis (16%) with other reasons as listed in Table 1.

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Component Design

Two different acetabular component designs were used in this study: a chamfered cylinder design (Zimmer, Warsaw, IN), and a hemispherical design (DePuy, Warsaw, IN). The chamfered cylinder design (CCD) was used between 1983 and 1990 in 85% (n = 150) of implants and was made by sintering commercially pure (CP) titanium fibermesh onto the outer surface of the Ti-6 A1-4 V alloy acetabular shell (Fig. 1A), which was designed to be used without screws. The fibermesh layer was 1.5 mm thick with a porosity of 35%–50% and pore sizes of 300–500 μm[14]. From 1986 to 1992, a hemispherical Ti-6 A1-4 V acetabular component with holes for screw fixation (Fig. 1B) and a porous beaded surface made from 200–300 μm diameter, commercially pure titanium beads, was also employed in 15% of implants.

Two different femoral component designs ranging from 36 to 51 mm with a mean of 40.5 mm were used. The first femoral component type was used from 1983 to 1990 in 78% of implants. This incorporated the same CP titanium fibermesh ingrowth surface as the acetabular component (Fig. 2A) and used a Ti-6A1-4 V alloy chamfered cylindrical configuration similar to the cemented first generation hip resurfacing, the Total Hip Articular Replacement by Internal Eccentric Shells (THARIES, Zimmer, Warsaw, Indiana), that it was designed from [15]. A second femoral component type composed of cobalt chromium with an ingrowth surface of sintered cobalt chromium beads of 75–100 μm (Fig. 2B) and a tapered cylindrical configuration of 3° was used from 1985 to 1992 in 20% of implants. The type of femoral component was unknown in 5 hips. Modular ultra-high molecular weight polyethylene inserts, gamma sterilized in air, with a thickness of 5 mm at the dome and 3.5 mm at the equator were used in all cases.

Surgical Technique

All procedures were done using a transtrochanteric approach. A circumferential capsulotomy commenced approximately 1 cm from the margin of the acetabular labrum and continued circumferentially parallel to it. Once the capsulotomy was completed, the femur was externally rotated to expose the entire femoral neck. The instrumentation was similar to that used in the THARIES resurfacing [15]. Using a cylindrical reamer guided by a Steinman pin, the pelvis and femur were reamed to provide an interference fit of 0.75 mm on the cylindrical region, and an exact fit for the chamfered and dome portions. Acetabular preparation was guided by a jig attached to the pelvis by threaded Steinman pins and secured by nuts using precision femoral cylindrical and chamfer cutting tools. The CCD component was 1 mm interference fitted and the component impacted and seated. More traditional techniques for the hemispherical model were used to achieve 10° to 15° of anteversion and 42° to 45° of abduction [16]. Femoral component preparation was achieved by a three-degree tapered cylindrical reamer. Bone obtained during reaming was used as bone paste for grafting of small cysts. The polyethylene liner was then placed into the metallic shell to the level of the lock tabs for a snap fit. Final seating was done using a hemispherical compactor.

Table 1
Demographic Data of the Uncemented Porous Surface Replacement.

Characteristic	Finding
Age	51.7 (15–79)
Gender	
Male	113 (64)
Female	64 (36)
Weight (kg)	77.7 (43–123)
Etiology	
Idiopathic osteoarthritis	95 (53)
Osteonecrosis	28 (16)
Developmental dysplasia	22 (12)
Posttraumatic osteoarthritis	11 (6)
Developmental or Metabolic	10 (6)
Rheumatic Disease	9 (5)
Infection	1 (1)
Tumor	1 (1)
Arthrogryposis	1 (1)

Fig. 1. Two different acetabular and femoral designs were utilized: (A) titanium fiber mesh acetabular component shown with a titanium fiber mesh femoral component and (B) titanium beaded acetabular component shown with a Co-Cr beaded femoral component.

Outcome Variables

The following variables were obtained using a systematic chart review based on the implant retrieval laboratory database, radiographs, and medical records at the time of surgery: 1) the type of component (acetabular or femoral) revised 2) the date of any revision, as well as revision of the original cup 3) the primary mode of implant failure for any revision.

All implants retrieved at revision from the senior author's surgical site were sent to one implant retrieval laboratory with a documented reason for revision based on the X-rays, patient symptoms, and intraoperative observations. For the present study, a comprehensive chart review was performed at the senior author's institution with systematic evaluation of the preoperative and operative revision notes to confirm the revision date, and document the specific component that was revised. In instances when an implant was revised at an outside institution, either the implant or surgical notes from the revision surgery were obtained. In 15 cases, while the revision date was known, the reason for revision could not be obtained. Institutional review board approval for this study was obtained.

Statistical Analysis

Survivorship analyses using the Kaplan–Meier method were performed for the following endpoints: 1) revision of either component for any reason (acetabular or femoral component) 2) revision of the cup for any reason 3) revision for acetabular loosening 4) revision for femoral loosening 5) revision for osteolysis of either or both components and 6) revision for neck fracture secondary to osteolysis. Chi squared analysis was performed to determine the certainty associated with differences between the rates of revision and loosening of different femoral ingrowth and acetabular ingrowth surfaces. All statistical analysis was conducted with SPSS (Version 13.0 for Windows, SPSS Inc, Chicago, IL).

Results

In this study, the mean follow-up time was 13.3 years (range 0.8 to 28.1 years, median 12.2 years). All patients had improved UCLA hip