ORIGINAL ARTICLE

Polyethylene Hip Resurfacing for Women

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Abstract

Background: Since 1995, most hip resurfacing procedures have been performed using a metal-on-metal prosthesis with excellent functional results. However, there have been concerns about metallosis, particularly for women. Also, there may be a higher early revision rate compared to total hip replacement. These concerns suggest there may be a role for polyethylene as the acetabular bearing surface for hip resurfacing. Currently available cross-linked polyethylene has superior wear characteristics and a lower failure rate compared to the polyethylene used in the past for both resurfacing and total hip replacement.

Methods: We performed 200 resurfacing procedures using a metal or ceramic femoral prosthesis and a polyethylene acetabular prosthesis. The procedures were performed as primary procedures or as acetabular only revisions for metal-on-metal resurfacing procedures that had failed due to metallosis. Either a one-piece cemented or two-piece acetabular component with a titanium shell and polyethylene insert was used. The patients averaged 51 years of age and 69% of the patients were women. The average follow-up was 4 years (range, 2 to 11 years). No patients were lost to follow-up.

Results: There were two infections. There were no dislocations. 95% of patients considered their procedure completely successful. Two patients underwent successful revision surgery for acetabular loosening. Four patients underwent successful revision to a total hip replacement for femoral neck fracture, femoral loosening, pain, or infection. There were no instances of osteolysis and there were no revisions for acetabular wear. Two patients had radiographic signs of polyethylene wear. None of the patients reported squeaking or clunking from their resurfaced hip. The mean Harris hip score was 93.

Discussion: Hip resurfacing with a polyethylene acetabular component is a reliable procedure at mid-term follow-up. Some of the concerns that exist – namely metallosis with metal-on-metal prostheses – can be avoided. The functional results are comparable to metal-on-metal resurfacing but long-term follow up is needed to determine if implant survivorship with polyethylene acetabular components will equal metal-on-metal prostheses. Polyethylene can be a useful option in acetabular revision situations or for women fearing metallosis.

Introduction

The current generation of metal-on-metal hip resurfacing arthroplasty is the fourth attempt at trying to preserve the femoral head and eliminate a femoral component inserted into the shaft of the femur. The first-generation implants were done on a limited basis using metal-on-metal, acrylic, or crude polymers.[10,23] The second generation used a cemented polyethylene acetabular component and usually a stemless femoral component. After initial enthusiasm, the high rate of failure from femoral component loosening, femoral neck fracture, and late acetabular loosening, led to abandonment of this technique.[1,6,8,22,30,32]

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The author certifies he has institutional approval for this investigation and the investigation was conducted in conformity with ethical principles of research and that informed consent was obtained.

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With a necessary large-diameter femoral head and thin polyethylene, wear debris was substantial, primarily because resurfacing patients were young and active.[22,32] The third generation of resurfacing prostheses used cross-linked polyethylene and a stemmed ceramic or metal femoral component.[27] These prostheses were never widely used. Due to concerns about polyethylene, when improved metallurgy was developed, a fourth generation of resurfacing prostheses was born. These implants are metal-on-metal and employ a so-called hybrid concept: a cementless, porous coated, non-modular (monobloc) acetabular component and a stemmed femoral component implanted with bone cement.[2,28]

The results of fourth generation prostheses have been better than early-generation prostheses except for smaller size patients (women), who have a heightened risk of an adverse reaction to wear debris (metallosis).[17]

We asked three questions: (1) What are the results of hip resurfacing using a cross-linked polyethylene acetabular component? (2) What are the complications of using polyethylene for hip resurfacing? and (3) What is the survivorship of hip resurfacing prostheses using polyethylene?

Development of Polyethylene

Polyethylene was not the initial choice of a polymer for hip arthroplasty. Sir John Charnley originally used polytetrafluorethylene (Teflon). The initial results were very positive but all of his implants failed over a few years. Charnley's technician, Harry Craven, was introduced to polyethylene by a bearing salesman and Charnley began using it in November, 1962. Charnley was opposed to the use of metal-on-metal, stating "Nevertheless, the conditions for film lubrication in a metal-to-metal joint must inevitably become less favorable as the diameter of the femoral head is reduced."[5]

In 1960, Dr. Charles O. Townley used polyurethane for hip resurfacing but over a few years the polyurethane wore away and he also moved to polyethylene.[23,24] Polyester and polyformaldehyde were also used but never became popular, as the results compared unfavorably with polyethylene in long-term follow-up.[16,31] Nylon was used unsuccessfully in a limited number of early procedures.[18] Recently, poly-ether-ether-ketone (PEEK) has been used successfully on an investigational basis.[20] New formulations of polyurethane have been developed but they are not approved for use.[21] Neither PEEK nor polyurethane is available at this time.

Polyethylene was originally rejected as a candidate material for both resurfacing and total hip replacement. It failed completely when used on the femoral side[6,19,31] but proved useful on the acetabular side.[14] Cross-linked polyethylene when used as a dual mobility (unconstrained tripolar) prosthesis, however, works well.[9] We now routinely use dual mobility prostheses if a femoral failure (fracture, loosening, or osteonecrosis) occurs following a successful resurfacing procedure. We also offer dual mobility prostheses as an alternative to treat metallosis occurring after resurfacing or total hip procedures. The dual mobility option permits a single component revision while preserving the natural femoral head geometry.

Polyethylene wears over time and its wear debris may cause osteolysis.[14-16] Cross-linking has reduced both wear and osteolysis considerably. All conventional hip prostheses today employ cross-linked polyethylene. Because of reduced wear, larger diameter femoral head prostheses are now used routinely.[7,12,13] Acetabular prostheses using cross-linked polyethylene are now manufactured with sufficient internal diameters to accommodate the natural femoral head preserved during hip resurfacing surgery (at least for smaller size individuals).[11]

Materials and Methods

For hip resurfacing we offered a polyethylene prosthesis to patients who had the following indications: (1) small femoral geometry (women), defined as a femoral head diameter of less than 46 mm, (2) prior adverse reaction to metal wear debris, and (3) concern for metal sensitivity. All patients were also offered the option of total hip replacement procedures. All patients were aware of the availability of metal-on-metal resurfacing prostheses.

All femoral prostheses were stemmed and either a modular magnesia-stabilized zirconium or cobalt-chromium femoral prosthesis was used (Figure 1). Femoral prostheses were used with or without cement.

The acetabular prostheses were either cemented in place or implanted without cement. The cementless prostheses were two-piece with a titanium backing and cross-linked polyethylene of a composite thickness of 10 mm.

Patients were allowed full weight bearing immediately and were evaluated annually. No limitations were placed on patients following their initial recovery. No blood transfusions were given.

Results

The follow-up ranged from 2 to 11 years. Forty-four patients had 2 to 3 years of follow-up, 51 had 8 to 11 years of follow-up, and 105 had 3 to 8 years of follow-up. No patients were lost to follow-up.

There were 200 resurfacing procedures using a polyethylene acetabular prosthesis and a metal or ceramic femoral prosthesis performed and prospectively followed. The average patient age was 51 years and 69% of the patients were women. Of the 200 procedures, 158 were performed as primary procedures (Figures 2A, 2B) and 42 were acetabular revisions for metal-on-metal resurfacing procedures that had failed due to metallosis.(Figures 3A, 3B, 3C)

Figure 1. This is a photograph of the two-piece acetabular component consisting of a porous titanium shell and a 44 mm polyethylene liner. The femoral component is zirconium with a curved modular stem.

For 179 procedures, a two-piece acetabular component with a titanium shell and a polyethylene insert was used. For 21 procedures the polyethylene was cemented to the acetabular bone.

There were two wound infections and three patients developed substantial heterotopic ossification. There were no dislocations or nerve palsies. Five patients continued to report pain: two had mild pain, two had moderate pain and one had substantial pain. Two patients, one with a cemented and one with a cementless acetabulum, underwent successful revision for acetabular loosening. Four

Figure 2A. This is an anteroposterior radiograph of a 49-year-old woman with severe osteoarthritis.

Figure 2B. The postoperative radiograph shows a hybrid resurfacing using a two-piece acetabular component a cemented cobalt-chromium femoral component.

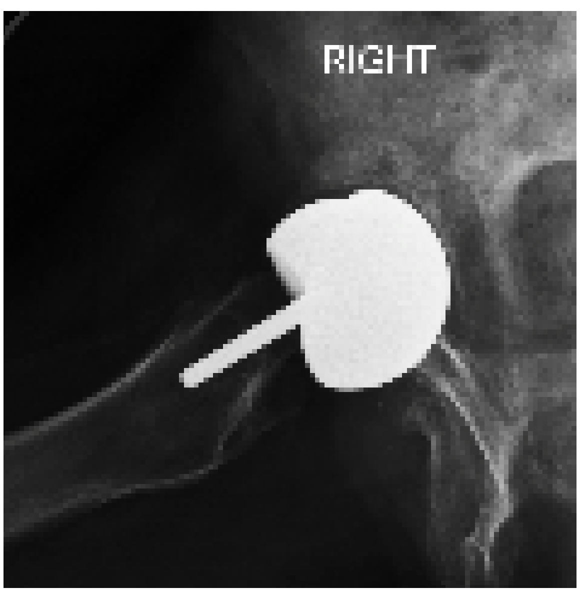

Figure 3A. This is a lateral radiograph of a 51-year-old woman who developed metallosis and acetabular loosening following a metal-on-metal resurfacing procedure.

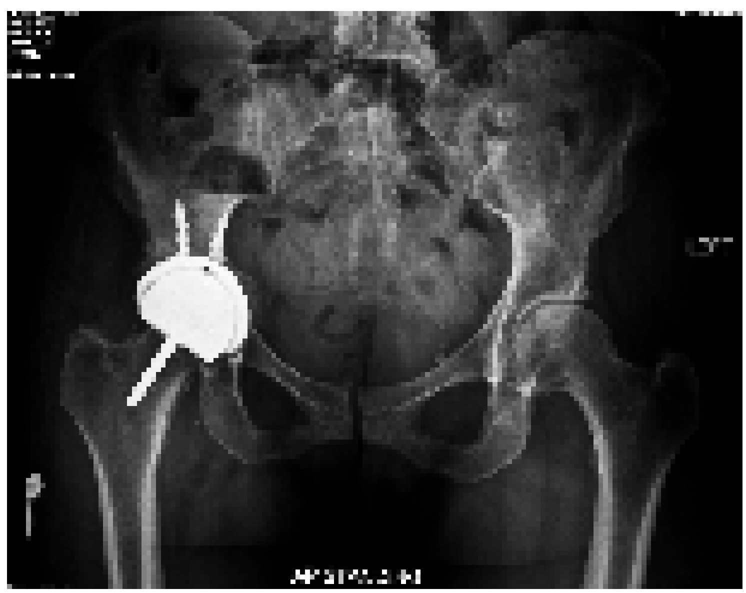

Figure 3B. This is an anteroposterior radiograph after successful revision of the acetabular prosthesis to a two-piece polyethylene bearing prosthesis.

patients underwent successful revision to total hip replacement for femoral neck fracture, loosening, persistent pain, or infection.

In three of the four revisions to total hip replacement procedures, the metal backing of the acetabular component was preserved and the acetabular liner was exchanged. In the fourth revision procedure, the cemented one-piece acetabular component was revised to a two-piece component. There was no appreciable wear at 2, 3, 5, and 6 years seen on the polyethylene.

There were no instances of osteolysis but two patients had radiographic signs of polyethylene wear at 7 and 8 years.(Figure 4A-B) No patients reported squeaking or clunking from their resurfaced hip. The mean Harris hip score was 93 and 95% of the patients claimed no functional limitations.

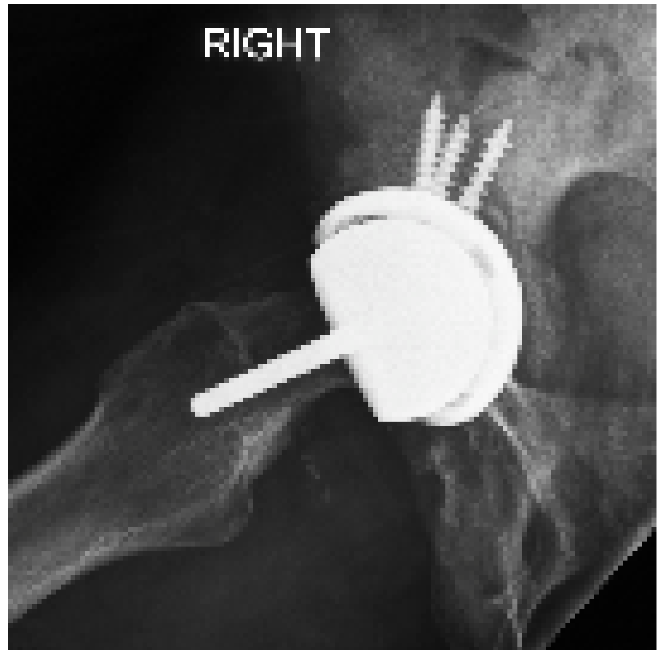

Figure 3C. This is a lateral radiograph after the acetabular revision

Discussion

Polyethylene has been an orthopedic bearing material since the 1960s.[5,14] It is chemically and conceptually simple; it is produced by the polymerization of ethylene gas into a macromolecular carbon chain with pendant hydrogen atoms. Cross-links, bonds that interconnect polyethylene molecules, can be produced by gamma or electron beam radiation. They are then annealed or re-melted by thermal treatments.[7] In 1998, highly cross-linked polyethylenes were introduced for clinical use. Clinical studies to date show a 50% to 87% reduction in wear.[7,12,13]

Figure 4A-B. This is an anteroposterior radiograph of a 44-year-old woman showing a cemented polyethylene acetabular component and cobalt-chromium femoral resurfacing prosthesis. On the left, thinning of the polyethylene is seen 8 years following implantation. On the right, the original thickness of the polyethylene is seen.

Cross-linked polyethylene has been produced and approved for use for femoral head diameters up to 46 mm. Some, but not all, studies have shown increased wear with femoral head diameters greater than 32 mm. There is substantial and favorable experience with femoral head diameters of 36 and 40 mm.[11,13,27] There is favorable wear simulator data from polyethylene diameters of 44 and 46 mm but no long-term clinical data are available.[11] Limiting oxidation has been an additional concern and polyethylene containing Vitamin E is now available.[4]

Early polyethylene prostheses were secured to the pelvis with polymethylmethacrylate during hip replacement or resurfacing procedures.[1,6,10,30,32] This was very successful but late loosening is common and, therefore, the use of porous-coated metal backing had become a very popular and successful alternative. Because cross-linked polyethylene can fracture, its thickness and the thickness of the metal backing are subject to engineering limitations. Most engineers recommend using a polyethylene thickness of 3.8 mm or greater and a composite thickness including the metal backing of 10 mm or more if a two-piece component is selected.

Cobalt-chromium alloys are used widely as bearing surfaces against polyethylene for hip and knee implants. Cobalt-chromium is harder and more resistant to corrosion than previous metals used in joint replacement, such as stainless steel. Titanium is much too soft to use as a bearing surface. Cobalt-chromium surfaces can be damaged and exhibit low wetability. Newer cobalt-chromium surfaces are superior to older implants with respect to smoothness. Ceramic materials generally offer harder and more hydrophilic surfaces compared to cobalt chromium and can be polished to a very low degree of roughness.[14]

Alumina-based ceramics have very favorable wear characteristics but there have been rare reports of implant fracture.[29] Reports of yttria-stabilized zirconia showed no reduction in wear when used with cross-linked polyethylene.[25] Oxidized zirconia has favorable wear results in hip simulator studies but has not been manufactured for use in resurfacing.[3] Magnesia-stabilized zirconia was chosen for use in our patients because of its superior wear characteristics in a hip simulator.[25] Also, there was no difficulty in preparing thin-walled stemmed prostheses appropriate for resurfacing applications.[21,27]

There are no long-term data available for using cross-linked polyethylene for resurfacing applications either with cobalt-chromium or ceramic prostheses. A nitrated (ceramized) resurfacing prosthesis has been used on a limited basis articulating with non-cross-linked polyethylene. The durability has been up to 11 years.[15]

Polyethylene should be reconsidered for resurfacing because of the superior wear characteristics of cross-linked polyethylene. Also, newer cobalt-chromium prostheses have reduced roughness. It will take many years to confirm the wisdom of this approach. When polyethylene wear occurs, it is anticipated that revision to another polyethylene bearing without disturbing the well-fixed metal shell will be possible. Women need not be denied hip resurfacing surgery.

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