Hip Resurfacing Arthroplasty

Michael A. Mont, MD
Phillip S. Ragland, MD
Gracia Etienne, MD, PhD
Thorsten M. Seyler, MD
Thomas P. Schmalzried, MD

Abstract

Hip resurfacing arthroplasty is a type of hip replacement that involves capping the femoral head and preserving bone of the proximal femur. Metal-on-metal surface replacements have been manufactured since the early 1990s. Recent studies indicate excellent clinical results with low failure rates at 1- to 5-year follow-up. Although these early results are encouraging, resurfacing devices must be used with caution because less is known about their long-term safety and efficacy. The best candidates for resurfacing are patients younger than age 60 years with good bone stock. The surgical approach is similar to that for standard total hip replacements, but with slightly more dissection because the femoral head must be preserved and displaced to visualize the acetabulum. To reduce complications, resurfacing arthroplasty should be performed by surgeons who have received training specifically in this technique.

Dr. Mont is Director, Center for Joint Preservation and Reconstruction, Rubin Institute for Advanced Orthopaedics, Sinai Hospital of Baltimore, Baltimore, MD. Dr. Ragland is Clinical Research Fellow, Center for Joint Preservation and Reconstruction, Rubin Institute for Advanced Orthopaedics, Sinai Hospital of Baltimore. Dr. Etienne is Attending Surgeon, Center for Joint Preservation and Reconstruction, Rubin Institute for Advanced Orthopaedics, Sinai Hospital of Baltimore. Dr. Seyler is Clinical Research Fellow, Center for Joint Preservation and Reconstruction, Rubin Institute for Advanced Orthopaedics, Sinai Hospital of Baltimore. Dr. Schmalzried is Associate Director, Joint Replacement Institute, Los Angeles, CA.

Reprint requests: Dr. Mont, Rubin Institute of Advanced Orthopaedics, Center for Joint Preservation and Reconstruction, Sinai Hospital of Baltimore, 2401 West Belvedere Avenue, Baltimore, MD 21215.

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Femoral resurfacing is a type of hip replacement that conserves bone in the proximal femur. The femoral head is prepared with bone cutting tools that enable the remaining femoral head to be capped, similar to the way in which a dentist caps a tooth. The femoral head either articulates with the native acetabular cartilage or is mated to an acetabular component.

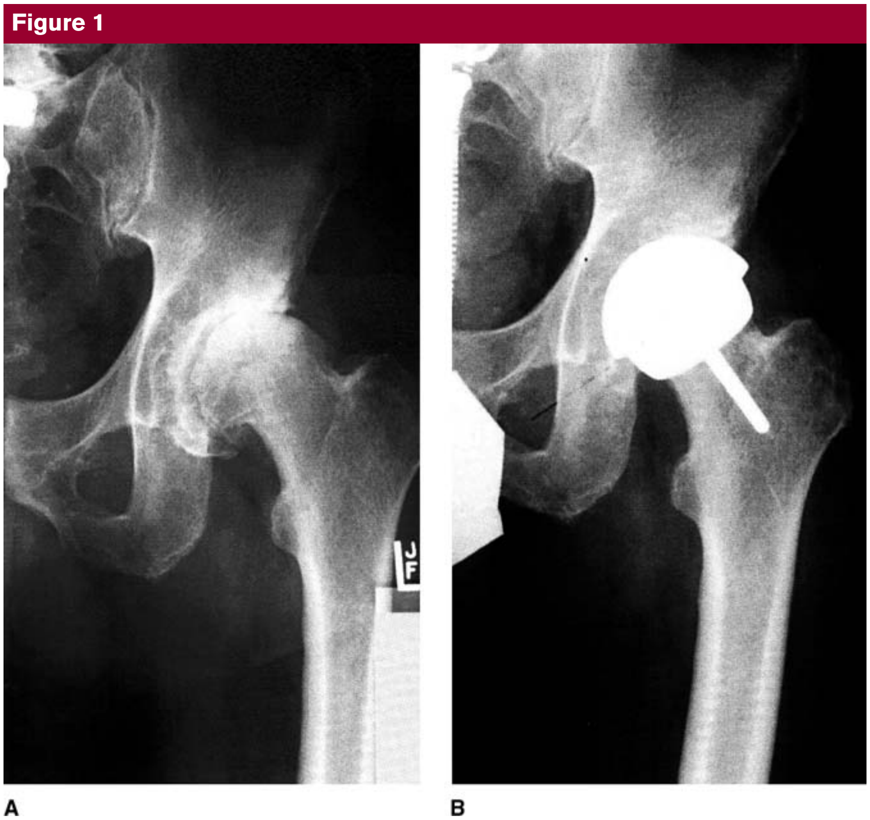
Hip resurfacing prostheses predate the use of stemmed femoral components. Various materials were used in the 1930s through the 1950s, including ivory, glass, and stainless steel. Femoral resurfacing coupled with cemented polyethylene acetabular resurfacing was popular in the 1970s, but it fell out of use because of high rates of bone resorption (osteolysis) and loosening within 5 years of surgery.[1-3] The use of a femoral resurfacing component alone to treat patients with late-stage osteonecrosis of the femoral head has been continuously employed through the present day. New metallurgy allows resurfacing with metal-on-metal articulations, and there has been a resurgence in the use of total hip resurfacing to manage many arthritides. Short-term results are excellent with resurfacing hip arthroplasty, but long-term results have yet to be published. To ensure optimal results, the surgeon must be aware of the indications and contraindications and should be specifically trained in resurfacing arthroplasty.

Resurfacing

Advantages

Resurfacing of arthritic joint surfaces with prosthetic components is the accepted and widely used standard in total knee replacement. Simple resurfacing of the worn joint surfaces has less frequently been used as a means of total hip arthroplasty (THA), however (Figure 1). Resurfacing has several theoretic advantages.

Figure 1



Preoperative (**A**) and postoperative (**B**) anteroposterior radiographs of a metal-on-metal resurfacing hip arthroplasty in a 46-year-old man who was treated for primary osteoarthritis.

Bone Preservation

One obvious advantage of resurfacing is that it preserves bone on the femoral side. It is preferable to retain the femoral head and avoid using the intramedullary devices that are implanted in standard hip replacements. However, resurfacing requires a more difficult surgical exposure to prepare the acetabulum without excising the femoral head and neck. For resurfacing to be truly conservative, the surgeon should not remove any more bone from the acetabulum than would be required for a THA, a goal that has only recently been addressed by companies manufacturing thinner acetabular shells.

Stress Transfer

An additional advantage of resurfacing hip arthroplasty is better stress transfer to the proximal femur. This may avoid long-term problems caused by stress shielding of the proximal femur, which can occur with intramedullary fixation of THA stems. Watanabe et al[4] found stress shielding below resurfacing prostheses, but Kishida et al[5] noted less loss of bone density of the proximal femur in resurfaced hips than in standard hip replacements.

Dislocation

A large femoral prosthesis (36 to 54 mm in diameter) is associated with a lower dislocation rate than conventional total hips with head diameters between 22 and 32 mm. In three large recent series, no dislocations of the hip were found.[6-8] In addition, resurfacing kinematically more closely resembles a normal hip and may have better proprioception than conventional THAs.[9,10]

Revision

Another theoretic advantage of resurfacing is that revision of the femoral component, when necessary, may be easier than revision of an intramedullary THA.[6,11] In the event of a femoral-side failure (eg, loosening, femoral neck fracture), the femoral neck can be cut below the prosthesis or fracture line and a conventional total hip stem inserted into the intramedullary canal. In addition, periprosthetic bone loss, which was often extensive with polyethylene acetabular resurfacing components, may be markedly reduced with metal-on-metal bearings. With early polyethylene acetabular resurfacing components, much bone was removed during insertion. Contemporary components have a metal acetabular bearing that requires removal of little acetabular bone stock. With femoral side failure, the acetabular component can be left in place and mated to a standard femoral component with a large-diameter femoral head[12] (Figure 2).

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Figure 2

Postoperative anteroposterior radiograph of a Big Femoral Head prosthesis (Wright Medical Technology, Arlington, TN). Note the large femoral head on a standard stem, which is mated with a resurfacing acetabular component.

Disadvantages

Hip resurfacing has several disadvantages. The lack of modularity of these devices reduces the ability to adjust leg length. Resurfacing is not appropriate in hips with loss of femoral head and neck bone stock or in hips with femoral cysts. In these patients, resurfacing may cause femoral neck fracture.

Femoral Neck Fracture

Femoral neck fracture is a unique complication of resurfacing, with an incidence ranging from 0% to 4%.[6-8,13-16] Fracture usually is found early in series, with declining rates as the surgeon overcomes the learning curve. For example, of 400 total hip resurfacing arthroplasties, Amstutz et al[6] reported three fractures, all of which occurred in the first group of 100. Mont et al[7] reported a high fracture rate in the first group of 50 hips resurfaced (22% [11 hips]), with one fracture in the next group of 50 (2%), and no fractures in the next 200 cases. In a recent study of 3,497 cases of hip resurfacing in Australia, 50 fractures occurred (incidence, 1.46%).[14]

The causes of fracture appear to be both patient- and technique-related. Patient-related factors include obesity, decreased bone mass, and inflammatory arthritis. Intraoperative characteristics that may lead to fracture include femoral neck cysts and exposed bone found during preparation. Surgical errors include notching of the femoral neck, tilting of the prosthesis into excess varus (<130° neck-shaft angle), and improper prosthetic seating. In the Australian national study,[14] the relative risk of fracture was twofold higher in women than in men ($P < 0.01$), and there was an increased risk of fracture with varus placement of the femoral component and with intraoperative notching of the femoral neck. Technical problems were noted in 85% of the cases with subsequent fracture.

Conversion to standard THA after fracture has not been difficult. The two options are completely revising both components or leaving the acetabular component in place with a standard stem, using a large femoral head to articulate with the cup.

Aseptic Loosening

Aseptic loosening has been found in some series. Amstutz et al[6] reported seven cases of femoral prosthesis loosening in their series of 400 hips. Most occurred in the first 100 cases and were attributed to intraoperative errors. Demographic factors that influenced loosening in this series included an average femoral stem shaft angle of 128.3°, which differed from that of the rest of the patients (average, 136°). In addition, in five of the seven hips with loosening, the authors found large areas of cystic degeneration of the head and remaining osseous defects, which were seen after bone preparation that diminished the surface area available for fixation.

Metal Degradation

Metal degradation may cause patient blood and urine metal levels to exceed levels associated with other bearing surfaces. The role of metal ions in relation to delayed type and humeral hypersensitivity reactions in patients with metal-on-metal implants remains unknown.

Metal-on-Polyethylene Resurfacing

Metal-on-polyethylene resurfacing was introduced in the 1970s as a bone-preserving alternative to conventional THA. Although short-term indications for most of these devices were promising, mid- and long-term follow-up yielded unacceptably high failure rates.[1-3] Failures were attributed to patient selection, surgical technique, and implant quality and design. The primary cause of failure, however, was polyethylene-induced osteolysis resulting from the mating of large metal femoral head components with thin-diameter polyethylene acetabular cups (Figure 3). Volumetric polyethylene wear was often 10 times higher than for standard hip replacements with head sizes ≤32 mm.[17] Because of these discouraging results, resurfacing arthroplasty fell out of favor in the early 1980s and only recently has regained some acceptance for managing osteonecrosis and other arthritides.

Metal-on-Metal Resurfacing for Arthritis

Metal-on-metal total hip prostheses with a conventional femoral stem were used in the 1960s but were abandoned in the 1970s because of the reported higher success rate of polyethylene bearings. The short-term failure rate was high secondary to aseptic component loosening, which was caused by multiple factors, including poor initial fixation, technical errors in device implantation, and problems with implant design and manufacturing. Design and manufacturing flaws produced high frictional torque that led to seizing and loosening. In the 1960s and 1970s, metal-on-metal articulations had wide ranges in manufacturing tolerance. With innovations in metallurgy, however, metal-metal bearings with tolerances <25 µm now can be manufactured.

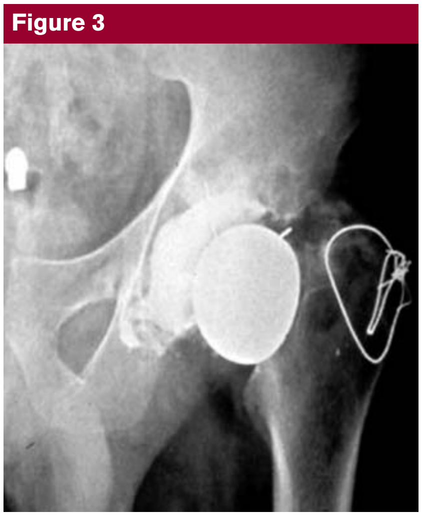
Many surgeons believe that modern metal-on-metal devices can reduce the incidence of long-term failure caused by aseptic loosening and osteolysis. It is hoped that wear particle generation and the associated osteolysis and implant loosening will be reduced; new metal-on-metal bearing surfaces have low reported particulate wear rates.[18] Recent advances in design have led to the introduction of polar bearing implants, which have reduced surface asperity. Designers have achieved superior fluid film lubrication for the bearing surfaces. The lubrication depends in part on the precision with which the implant bearing surfaces are manufactured. Surface asperities must have lower dimensions than the thickness of the fluid film to achieve fluid film lubrication. This, in turn, should minimize both frictional torque on the implants and the generation of wear particles. Some studies have shown much lower numbers of wear particles generated by metal-on-metal bearings than by metal-on-polyethylene bearings;[17,19] however, this may not be true with modern prostheses. Small clearance between the femoral head and acetabular component in metal-on-metal devices can be achieved with large-diameter heads. This in turn may enable greater fluid film lubrication and, subsequently, less wear and less metal ion production. In a recent study, diametrical clearance of 300 µm produced considerably more wear than same-diameter heads with smaller clearances.[20]

The advantages of metal-on-metal bearings must be balanced against the possible adverse effects of particulate metal debris. Several studies[18,21-23] have shown increased levels of metallic ions in body fluids and adjacent tissues after joint arthroplasties with metal-on-metal bearings. Clarke et al[18] noted increased metal ions in two resurfacing designs, compared with a standard metal-on-metal implant with a 28-mm head. Additionally, metal ions may cause allergic hypersensitivity.[24] Despite occasional anecdotal reports of possible tumor induction by metal implants, whether with metal-on-metal or metal-on-polyethylene bearings, no evidence has been published to directly link metal-on-metal bearing surfaces with adverse biologic effects. Although elevated metal ions are found in patients and there is a theoretic possibility that metal ions may lead to metal hypersensitivity, the significance of these factors has yet to be determined. Several studies report information regarding particulate debris from metal-on-metal bearing couples.[18,21,23]

In the early period of resurfacing arthroplasty, osteonecrosis of the femoral head was proposed as a cause of failure.[25,26] Campbell et al[25] histologically examined 25 resurfaced femoral heads removed at revision and found only viable bone, with minimal evidence of femoral head necrosis at 15 to 144 months after surgery. Only 12% of the specimens had any osteonecrosis; these patients had prior fractures and surgeries that may have damaged the head vasculature. The areas found were small and did not cause the resurfacing failure. Bell et al[27] reported similar findings, with only 1 case of osteonecrosis in 18 cases of failure of the Wagner device (Sulzer Limited, Winterthur, Switzerland) at mean of 2 years postoperatively.

The viability of the femoral head may not necessarily be important for excellent results. In a study of resurfacing in patients with osteonecrosis, excellent results were reported for 26 of 27 hips at 2-year follow-up.[28] Longer follow-up is needed on these hips. Thus, it remains to be determined whether femoral head viability has an impact on resurfacing survival.

Figure 3



Anteroposterior radiograph demonstrating a failed hip resurfacing combined with a thin polyethylene liner. The primary cause of failure is polyethylene wear and osteolysis.

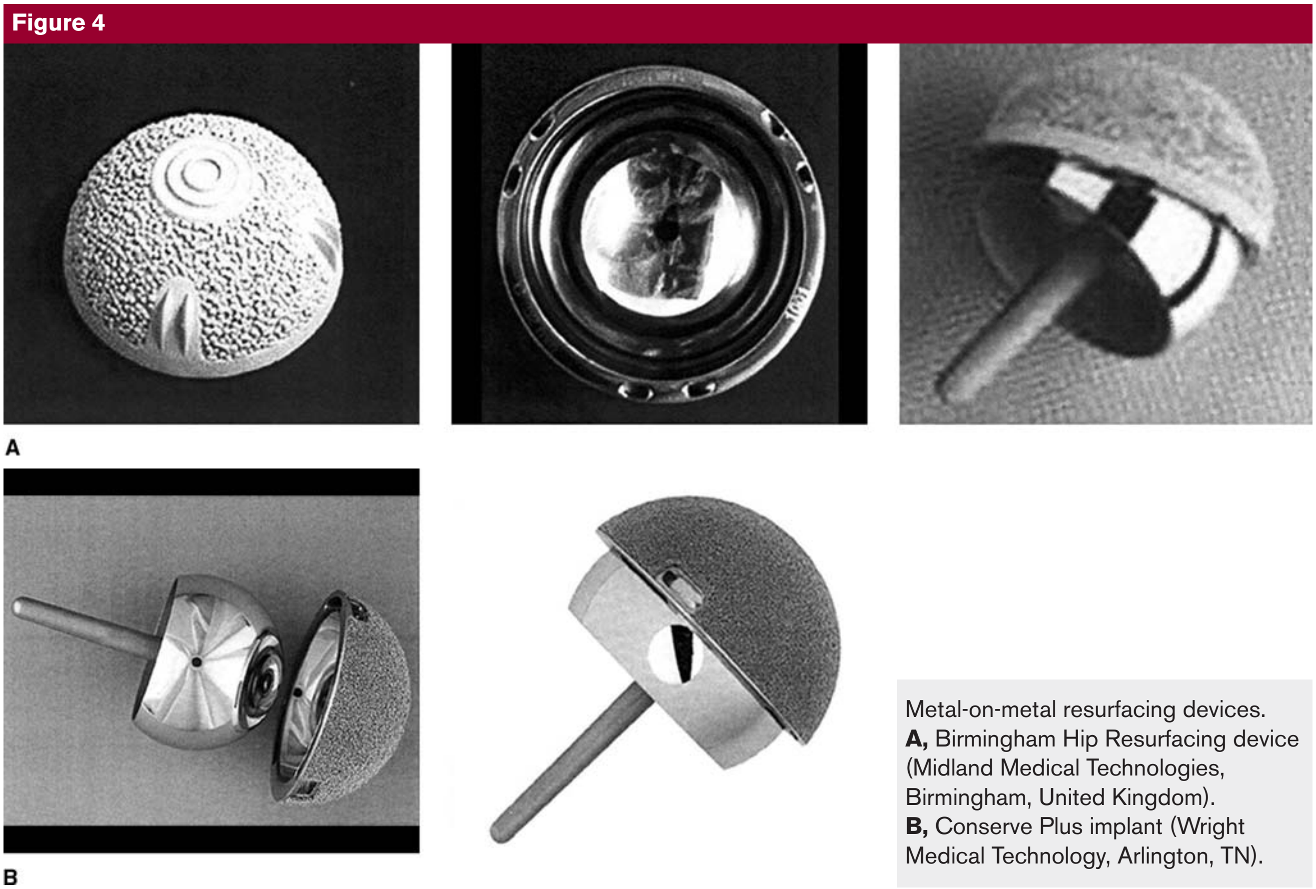
Recent Prostheses

Metal-on-metal surface replacements have been used since the early 1990s. Most devices feature cobalt-chrome components for cementless fixation on the acetabular side and cemented fixation on the femoral side (Figure 4).

Second-Generation Metal-on-Metal Resurfacing

Unfortunately, there are few published studies of resurfacing THA done with modern designs (Table 1). Daniel et al[8] studied 446 hip resurfacings in 384 patients using the McMinn Resurfacing Hip Arthroplasty (Corin Medical, Cirencester, United Kingdom) and the Birmingham Hip

Figure 4



Metal-on-metal resurfacing devices. **A,** Birmingham Hip Resurfacing device (Midland Medical Technologies, Birmingham, United Kingdom). **B,** Conserve Plus implant (Wright Medical Technology, Arlington, TN).

Resurfacing (BHR) prosthesis (Midland Medical Technologies, Birmingham, United Kingdom) implanted between March 1994 and April 2001, but excluding 1996. The McMinn device was implanted in 43 hips from 1994 to 1995, and the BHR was used in 403 hips between July 1997 and April 2001. Both devices consisted of a cemented femoral component and a hydroxyapatite-coated acetabular component. All patients were younger than age 55 years, and mean follow-up was 3.3 years (range, 1.1 to 8.2 years). The authors reported only one revision in a group of patients with high-level occupations and recreational activities (1/446 [0.02%]). Importantly, the authors excluded 186 patients operated on in 1996 who had a different device that was found to be defective. That device had two post-cast heat treatments, which led to microstructural changes in the metal, deterioration of wear characteristics, and early failure from metallosis and osteolysis.

Three recent studies have examined implant stability and proximal femoral bone density after BHR implantation. Glyn-Jones et al[36] recently described a roentgenostereophotogrammetric analysis (RSA) of the BHR component in 22 hips. RSA was used to evaluate the hips at 3-month intervals up to 24 months. At last follow-up (24 months), the total migration of the head was 0.2 mm, which was not statistically significant. The authors concluded that the BHR femoral component is a stable device.

Kishida et al[5] analyzed proximal femoral bone mineral density in 26 hips, half of which had a BHR component (group A) and half, a proximally coated cementless standard THA (group B). Loss of bone mineral density was less in group A ($\leq 1\%$ in any radiographic zone) than in group B ($\leq 17\%$ for certain zones; $P =$ 0.04 to 0.08, depending on the zone analyzed). The authors concluded that the BHR component preserves proximal femoral bone stock by transferring load to the proximal femur in a more physiologic manner than do long-stem devices, thus preventing stress shielding.

Watanabe et al[4] conducted a finite element analysis study of the BHR implant and found stress shielding in the anterosuperior region of the femoral neck beneath the prosthesis as well as stress concentration around the short stem in the inferior cross-section of the femoral neck. The authors speculated that this may lead to fracture and long-term loosening. Yoo et al[32] recently reported on 40 hips with osteonecrosis managed with a BHR implant. At mean follow-up of 4 years, there were no complications, osteolysis, or component loosening.

Beaule et al[16] studied 94 hips (83 patients) resurfaced with the Con-

Table 1

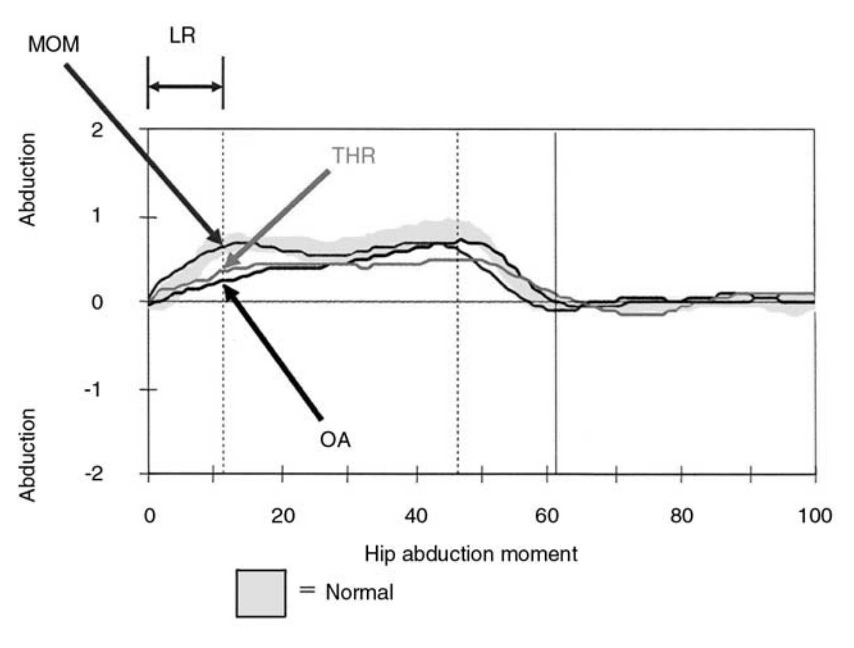
Results of Studies Using Metal-on-Metal Total Hip Resurfacing

Study	Prosthesis	No. of Hips	Follow-up (mos)	Clinical Success Rate (%)
McMinn et al[29]	Cementless, uncoated design	70	50.2 (range, 44-54)	87
	Cementless, hydroxyapatite-coated design	6	40.2 (range, 38-42)	100
	Cemented design	43	33.2 (range, 23-38)	91
	Cemented femoral design and cementless, hydroxyapatite-coated acetabular design	116	8.3 (range, 1-19)	100
Schmalzried et al[30]	Wagner prosthesis (Sulzer, Winterthur, Switzerland)	4	16 (range, 10-25)	100
	McMinn prosthesis (Corin Medical, Cirencester, United Kingdom)	17	16 (range, 10-25)	100 (progressive cement bone interface radiolucencies in 71%)
Wagner and Wagner[31]	Wagner prosthesis	35	20 (range, 6-54)	86
Amstutz et al[19]	McMinn prosthesis and Wagner prosthesis	50	(12-48)	74
Daniel et al[8]	McMinn prosthesis	43	40 (range, 13-98)	81
	Birmingham Hip Resurfacing (BHR) system (Smith and Nephew, Memphis, TN)	403	40 (range, 13-98)	100
Yoo et al[32]	Birmingham Hip Resurfacing (BHR) system	40	36.8	100
Beaule et al[16]	Conserve Plus (Wright Medical Technology, Arlington, TN)	94	36 (range, 24-60)	97
Amstutz et al[6]	Conserve Plus	400	42 (range, 26-74)	94
Etienne et al[28]	Conserve Plus	30	24 (range, 12-48)	97
Treacy et al[15]	Birmingham Hip Resurfacing (BHR) system	144	72	98
Beaule et al[13]	Conserve Plus	56	58.8 (range, 28-100)	95
Mont et al[33]	Conserve Plus	84	41 (range, 26-61)	98
Beaule et al[34]	McMinn prosthesis	42	104 (range, 86-120)	79
Schmalzried et al[35]	Conserve Plus	81	24	98

serve Plus metal-on-metal total resurfacing device (Wright Medical, Arlington, TN). They included only patients who had a minimum 2-year follow-up or who had undergone revision. Mean age was 34 years (range, 15 to 40 years). Based on their analysis of 3 hips that required revision and 10 hips that had impending failure, the authors calculated a surface arthroplasty risk index (4.7 for 13 problem hips, 2.6 for remaining hips) to predict the risk of failure. Factors leading to increased risk included prior surgery, femoral cyst >1 cm, and valgus positioning of the stem.

Amstutz et al[6] reported 2- to 6-year follow-up of the first 400 hips (355 patients) implanted with the Conserve Plus device. Patient mean age was 48 years (range, 15 to 77 years). The overall rate of survival at 4 years was 94.4%. Patients with a high surface arthroplasty risk index (>3) demonstrated a survival rate of 89%, compared with 97% for those with a low risk index (≤3). Twelve

Figure 5



Hip abduction moments. Resurfaced hips have close to normal (shaded) abduction moments, which are greater than in patients with standard total hip replacement (THR). Patients with osteoarthritis (OA) have the lowest abduction moments. LR = loading response, MOM = metal-on-metal

hips were revised to a standard THA (3%). Of those 12 hips, 7 were revised because of loosening, 3 because of femoral neck fracture, and 1 each because of recurrent subluxation and infection. Most complications occurred in the first 100 hips operated on, indicating the learning curve involved in proper resurfacing implantation. Revision was straightforward. Important risk factors for femoral component failure included large femoral head cysts, patient height, and female sex.

Mont et al[9] compared gait characteristics of resurfacing patients with healthy hips, patients with osteoarthritic hips, and patients with standard THAs. Patients with resurfacing walked faster (average, 126 m/s), comparable with the walking speed in normal subjects. Patients with osteoarthritic hips and standard THAs walked at significantly slower speeds (96 and 99 m/s, respectively; $P < 0.001$ for both groups). There was no significant difference in hip abductor and extensor moments between patients with resurfacing and patients with healthy hips. The hip abductor moment in osteoarthritic and standard THA groups was significantly reduced ($P < 0.05$) compared with the normal group (Figure 5). Patients with resurfacing hip arthroplasty demonstrated superior hip kinematics compared with standard hip replacements. However, the series was neither prospective nor randomized, and although patients were retrospectively matched, the study may have been subject to selection bias.

Silva et al[10] studied the biomechanical results of resurfacing, comparing the joint reactive force of 50 resurfaced hips with that of 40 hips managed with standard cementless THA. The authors reported that the biomechanical results of hip resurfacing were dependent on the preoperative anatomy of the proximal femur. Limb lengthening can be achieved, but horizontal offset is essentially unchanged by resurfacing. In contrast, when necessary, both parameters can be increased reliably in standard THAs. The authors concluded that arthritic hips that are at least 1 cm shorter than the contralateral limb or that have low horizontal femoral offset may be better managed with a standard THA.

Etienne et al[28] implanted 30 metal-on-metal Conserve Plus resurfacing components in patients with late-stage osteonecrosis. At a mean follow-up of 2 years (range, 1 to 4 years), they reported only one failure, which was caused by a femoral neck fracture.

Indications and Contraindications

Advocates of hip resurfacing believe that the indications are similar to those for any standard THA, with certain provisos. Table 2 provides a list of absolute and relative contraindications as well as instances in which to use these devices with caution. Patients who are considering resurfacing should be counseled that, compared with standard THA, less is known about the long-term safety and efficacy of resurfacing devices and the outcome of revision surgery.

Contraindications for resurfacing include deficiency of femoral head or neck bone stock, and a small or bone-deficient acetabulum. The hip with loss of femoral head bone stock after a fracture or other causes, such as rapidly progressive osteoarthritis ("disappearing bone disease"), cannot be resurfaced. When large femoral neck or head cysts are encountered, resurfacing may be inappropriate (Figure 6). The best candidates for metal-on-metal resurfacing are patients younger than age 60 years with good bone stock.

Amstutz et al[19] described three especially good indications for undertaking resurfacing rather than standard THA surgery: (1) patients with proximal femoral deformity, which makes standard stemmed prostheses difficult to place (Figure 7); (2) patients with a high risk of sepsis because of prior infection or immunosuppression; and (3) patients with a neuromuscular disorder. (A large-diameter ball reduces dislocation risk in patients with a neuromuscular disorder). Based on our experience, two other excellent indications for resurfacing are (1) retained hardware that would be difficult to remove for a standard stem placement (Figure 8), and (2) patients with conditions with a high risk for failure using standard THAs (eg, sickle cell disease; alcoholism, which has a high dislocation rate).

Table 2

Contraindications to Metal-on-Metal Hip Resurfacing

- Absolute contraindications
  - Loss of femoral head (severe bone loss)
  - Large femoral neck cysts found at surgery
  - Small or bone-deficient acetabulum
- Relative contraindications
  - Poor bone stock (assessed via DEXA scans)
  - Chronologic age >65 years
  - Body mass index >35
- Use with caution
  - Patient with rheumatoid arthritis
  - Tall and thin patient
  - Female patient
  - Patient with femoral head cyst >1 cm as demonstrated in preoperative radiograph
  - Patient with osteonecrosis of the femoral head

DEXA = dual-energy x-ray absorptiometry

Surgical Techniques

Resurfacing can be performed with standard approaches used in conventional THA. No studies have compared the two major approaches: anterior and posterior. We have used both approaches. Anterior approaches have been used in an attempt to preserve blood supply to the femoral head, but most surgeons use posterior approaches that retain the capsule, with no adverse effects on the blood supply. More dissection is usually involved in resurfacing THA because the femoral head has to be preserved and displaced to visualize the acetabulum. Reaming of the acetabulum is performed routinely, but sufficient bone must be taken to allow placement of an appropriately sized femoral component without notching the femoral neck. When too-small an acetabular component is placed, it necessitates a smaller femoral component, which may preclude using a component that completely surrounds the femoral neck. Fortunately, most modern designs are made with thin components that do not require excessive reaming away of acetabular bone.

All modern acetabular components are made for cementless press-fit insertion. On the femoral side, components usually range in size from 36 to 54 mm; they are placed with various positioning devices around the femoral neck to mimic the native femoral head. The femoral neck is of paramount importance; the surgeon must avoid notching any part of it, especially the lateral cortex, to avoid a stress riser, which could lead to femoral neck fracture. Most components have a small, thin, straight stem that enters the femoral neck or extends slightly beyond into the intertrochanteric area. The femoral head is prepared with two reamers to mimic the inner geometry of the femoral components, which are almost always cemented in place. Recently, techniques have been developed with new instrumentation that enable the use of smaller incisions.[37] Resurfacing arthroplasty should be performed only by the surgeon who has received training specifically in this technique.

Figure 6

Intraoperative photograph of a cyst, which precluded hip resurfacing. The patient received a conventional total hip replacement.

Future Directions

In the future, use of ceramic-on-ceramic resurfacing may be possible. Such interfaces are presently precluded because of the thickness of

Figure 7

Postoperative anteroposterior **(A)** and lateral **(B)** radiographs of a patient with posttraumatic extra-articular proximal femoral deformity secondary to trauma, who was treated with resurfacing hip arthroplasty.

Figure 8

Postoperative anteroposterior radiograph of a patient in whom an intramedullary rod was placed to correct a bowing deformity of the femur. The patient underwent hip resurfacing rather than a conventional total hip replacement to avoid removal of the femoral intramedullary rod.

ceramic necessary, which would not be bone-sparing on the acetabular side. With newer materials, ceramic-on-polyethylene articulations may be a possibility. Such devices previously failed because of polyethylene wear. With the advent of newer, highly cross-linked polyethylenes, which have superior wear characteristics, there may be a return to this material as a bearing surface.

Summary

Many of the technical problems that affected early resurfacing implants have been identified and resolved with improved engineering and manufacturing techniques. Recent studies have demonstrated excellent short-term results with metal-on-metal resurfacing in patients younger than 60 years of age. Cementless acetabular components are mated to cemented femoral components because of the unsatisfactory results of cemented acetabular fixation. Although the loosening and fracture risk is relatively low, there are certain at-risk demographic populations, such as women, patients older than 60 years of age, patients with poor bone stock, and patients with inflammatory arthritis. The risk of dislocation is much lower than for standard THAs. The true incidence of osteonecrosis of the femoral head under the component is low. Converting failed resurfacing to standard THA is relatively straightforward. The resurfacing procedure has a learning curve, with a higher rate of failure in the initial patients. Long-term follow-up of metal-on-metal resurfacing implants is necessary to determine the appropriate use of these devices. Surgical techniques for implantation likely will evolve as use becomes more widespread.

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Evidence-based Medicine: There are no level I or II randomized prospective studies. Reported are level III and IV case-control series.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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