# Adverse reaction to metal debris: metallosis of the resurfaced hip

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## ABSTRACT

The greatest concern after metal-on-metal hip resurfacing may be the development of metallosis. Metallosis is an adverse tissue reaction to the metal debris generated by the prosthesis and can be seen with implants and joint prostheses. The reasons patients develop metallosis are multifactorial, involving patient, surgical, and implant factors. Contributing factors may include component malposition, edge loading, impingement, third-body particles, and sensitivity to cobalt. The symptoms of metallosis include a feeling of instability, an increase in audible sounds from the hip, and pain that was not present immediately after surgery. The diagnosis is confirmed by aspiration of dark or cloudy fluid from the effusion surrounding the hip joint or by laboratory testing indicating a highly elevated serum cobalt level. Metallosis can develop in a hip with ideal surgical technique and component placement; conversely, some patients with implants placed with less than ideal surgical technique will not develop this complication. Among patients with bilateral hip implants, if metallosis develops it may involve only one hip. Bone loss and tissue necrosis can develop if metallosis is untreated and continues to progress. Surgery is the only effective treatment for progressive metallosis. If there is adequate bone remaining, the acetabular component can be repositioned, keeping the metal-on-metal resurfacing prosthesis. In some patients, it also is possible to change the bearing surface to metal-on-polyethylene. Total hip replacement is an alternative for patients whose resurfacing procedure is complicated by metallosis. Advanced cases may present additional challenges; thus, early surgery is recommended.



**Keywords**
chrome-cobalt, hip resurfacing, metallosis


## INTRODUCTION

Adverse reaction to metal debris, herein termed metallosis, usually is defined as aseptic fibrosis, local necrosis, or loosening of the prosthesis secondary to metallic corrosion and release of wear debris.[1–3] It has been characterized as a grey discoloration of the tissues of the joint, pain, an effusion, and elevated serum metal levels. Metallosis has been found with stainless steel, titanium, and cobalt-chromium alloy femoral prostheses articulating either with a similar metal or (rarely) with a polymer acetabular component. Titanium and stainless steel femoral head prostheses are no longer used, so today metallosis usually refers to tissue changes observed after the use of cobalt chromium-on-cobalt-chromium (metal-on-metal) implants. Metal-on-metal hip prostheses have been in common use for total hip replacement and almost all current hip resurfacing prostheses are metal-on-metal.[4] This report presents an in-depth review of metallosis in association with metal-on-metal hip resurfacing.

## COBALT AS A BEARING SURFACE

Cobalt is a transition metal. Transition metals have many uses and are valued for their strength. Cobalt is found in vitamin B12 and is essential for oxygen transport.[5] Cobalt occasionally produces dermatitis, but there is less hypersensitivity to cobalt than to other metals, such as stainless steel and other nickel-containing alloys.[6]

A cobalt-chromium hip prosthesis was first used in 1938 for cup arthroplasty by Smith-Peterson.[7] The original alloy (Vitallium) was used in dentistry for bridges, dentures, and orthodontia. Bohlman[8] first used a Vitallium femoral head and neck replacement in 1939 by attaching a Vitallium ball to a tri-flanged nail. Moore and Bohlman[9] performed the first successful femoral head prosthesis implantation in 1940. Vitallium was attractive as an implant material because of its corrosion resistance and electrolytic inertness. All implants will ionize after implantation but cobalt-chromium remains the most corrosion resistant.[9–11] In 1951, McKee began using stainless steel for total hip replacement but all prostheses failed. He began using a cobalt-chromium Thompson prosthesis in 1956 and refined his metal-on-metal McKee-Farrar Prosthesis in 1966 (Figure 1).[12–14] Townley and Walker[15] originally used stainless steel for femoral head resurfacing in 1951 but also quickly moved to cobalt-chromium. The Peter Ring prosthesis, starting in 1964, also used cobalt-chromium.[16] Urist,[17] McBride,[18] and Müller[19] all used cobalt-chromium but Charnley[20] used stainless steel, articulating it with polyethylene after a failed attempt using Teflon.

## COBALT LEVELS

Serum cobalt levels are useful in predicting the presence or absence of metallosis. All patients with metal-on-metal hip prostheses have elevated levels of cobalt detected in their


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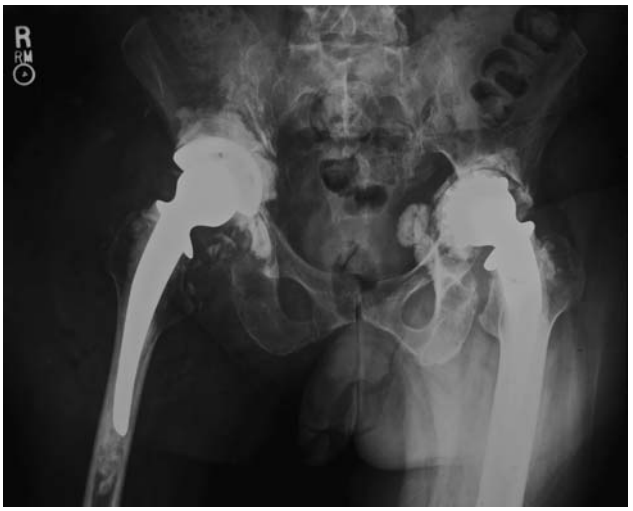

**FIGURE 1.** Anteroposterior radiograph of the pelvis in a 58-year-old woman 40 years after receiving bilateral McKee-Farrar total hip replacements. On the left, the original metal-on-metal prosthesis demonstrates acetabular loosening. On the right, a revision using a custom-made, two-piece titanium and polyethylene acetabular prosthesis has been performed.

hair, blood, urine, vital organs and, if present, placenta.[21] Thus, the cobalt level should be measured several months or a year after surgery to avoid a misleading result caused by the wearing-in process of the prosthesis.[22,23] For unilateral metal-on-metal joint resurfacing, a cobalt level $\leq 4\,\mu g/L$ can be expected and for bilateral resurfacing the cobalt level is generally $< 9\,\mu g/L$. Cobalt levels $> 100\,\mu g/L$ can be found occasionally. Patients with equivocal levels should be followed over time with repeated testing. If the cobalt level is increasing, metallosis should be suspected. In some laboratories, testing of the joint fluid is possible but usually the appearance of the aspirated fluid alone is diagnostic of metallosis (Figure 2).

Tower[24] reported two patients with replaced hips implanted with Articular Surface Replacement (DePuy Orthopaedics, Inc., Warsaw, IN) who developed systemic cobalt poisoning. The manufacturer recalled these bearings in August of 2010 because of a failure rate of more than 12% in the first 5 years of implantation from metallosis. At revision, both patients had extremely high levels of cobalt along with gross metallosis of the periprosthetic tissues. This was the first published report of systemic cobalt poisoning in association with metal-on-metal hips.[24] Jacobs[25] raised some questions about this report with regard to the need for more information about implant orientation and the methodology of metal measurement in serum. There have been no documented reports of systemic cobaltism with resurfacing prostheses.

## SENSITIVITY TO COBALT

Nearly 40 years ago, laboratory wear studies showed that cobalt-chrome alloy articulating components released cobalt and chromium into solution and that patients implanted with these prostheses had elevated levels of cobalt and chromium in their blood and urine.[26] Evans *et al.*,[27] in

**FIGURE 2.** Syringe shows joint fluid that has been aspirated from a patient with metallosis 2 years after hip resurfacing surgery.

1974, described metal ''sensitivity'' as the cause of bone necrosis and prosthetic loosening in a small cohort of patients with hip and knee total joint replacements using cobalt-chrome alloy. They studied 14 patients (16 loose prostheses) and found that eight patients were sensitive to cobalt, one to chromium, and one to nickel. They also noted that of 24 patients whose implants were not loose, none had sensitivity to these materials.[27]

Hypersensitivity from cobalt can occur, but it is relatively rare, and there is no validated test to establish the diagnosis before implantation of a cobalt prosthesis.[6] True hypersensitivity is very rare, but most patients with metal-on-metal prostheses will react to skin tests for cobalt sensitivity. However, when the cobalt prosthesis is removed, skin tests become negative, suggesting the patients are likely not hypersensitive. Therefore, there is no validated way to determine hypersensitivity to cobalt after implantation of a cobalt-containing joint prosthesis.

Metal-on-metal prostheses present a large surface area to surrounding body fluids. The metal prosthesis must achieve equilibrium with the surrounding body fluids to avoid a local accrual of metal ions to a toxic level in the joint. As the cobalt is generated, it must be absorbed by the lymphatics and synovial tissues. It is then circulated and excreted through the urine. The ability to excrete cobalt varies with renal function. Patients with impaired renal function are not candidates for metal-on-metal joint prostheses.

## TISSUE REACTION TO ELEVATED COBALT LEVELS

There is no consensus of the description of the different adverse tissue reactions to metal debris. Aseptic lymphocyte-dominated, vasculitis-associated lesion (ALVAL) is a histological diagnosis that describes the necrotic tissue and fluid seen at revision surgery. The term ''metallosis'' also has been defined as aseptic fibrosis and local tissue necrosis with or without implant loosening. Some patients show a mixture of different tissue reactions. In 1988, Svensson *et al.*[28] published the first report of pseudotumor in association with an uncemented total hip arthroplasty. This patient did not have a metal-on-metal hip prosthesis.

Starting in 2008, reports of ''pseudotumours'' occurring after metal-on-metal resurfacing began appearing in the literature, and such cases are now reported regularly.[29] Pseudotumor has been described by Liu *et al.*[30] as ''a soft-tissue mass associated with the implant, which is neither malignant nor infective in nature.'' Most authors associate pseudotumor with an effusion that can be very large. There is conflicting information about the incidence and predisposing factors. Implant manufacturers and some surgeons report that women or smaller size patients, with or without steep abduction angles, are more likely to develop metallosis.[3,23]

Pseudotumors regress when the local cobalt level is reduced, either by removal or revision of the prosthesis; thus, there is no need to resect the involved tissues aggressively. Osteolysis and further tissue necrosis, however, will follow if treatment is not provided. There is no non-operative treatment for pseudotumors or progressive metallosis.

In some patients the tissue reaction is mixed; with pseudotumor formation, the tissues are overgrown but in other instances the tissues become avascular and necrotic. Thickened fibrotic soft tissues can be found immediately adjacent to the necrotic tissue. The underlying bone can be avascular with a dead-appearing surface.[13,31]

Rarely, patients present with little pain but have severe soft-tissue necrosis, osteolysis, or both. The presenting symptom can be a spontaneous dislocation as the soft tissues are lost or a periprosthetic fracture. The first literature reports describe several such cases. This presentation represents the most substantial challenge for later reconstruction.[31–33] Sometimes patients have more than one type of tissue reaction to the elevated cobalt level or the primary tissue response evolves from one type to another over time. It is unknown why some patients respond differently than others.

## FIRST REPORTS OF METALLOSIS ASSOCIATED WITH METAL-ON-METAL HIP PROSTHESES

McKee,[12] in 1971, first reported metallosis after metal-on-metal total hip replacement in two patients who developed pain 3.5 and 4.5 years after total hip replacement. Both had sterile necrotic material at exploration.[13] In 1975, Jones *et al.*[31] reported seven additional patients who developed symptoms of progressive pain and a feeling of instability between 9 months and 4 years after a McKee-Farrar total hip replacement. Bone loss with soft-tissue necrosis was found in all patients, and two patients had spontaneous dislocations.[31] The tissues were stained green or grey, and paste-like material was found around a thickened capsule. Highly elevated levels of cobalt were detected in the serum and joint fluid. Large joint effusions with either rust, green, cloudy yellow, or grey-colored fluid were found in all patients.[13,31] McKee-Farrar prostheses were manufactured as a matched set with the acetabular component made, matched, and tested to accompany the femoral prosthesis.[12] This manufacturing technique would be desirable today, but no manufacturer offers implants prepared and tested together. McKee-Farrar hip replacement was abandoned in the early 1970s as other prostheses proved more successful.

## METALLOSIS WITH MODERN METAL-ON-METAL RESURFACING

Metal-on-metal hip resurfacing was first performed by Haboush in 1951[34] and occasionally by others until the mid-1970s.[19,35,36] There was no mention of metallosis in the early published reports. With improved metallurgical technology, metal-on-metal resurfacing began to be used again in 1988. It increased in popularity, and in 2006, a full Food and Drug Administration (FDA) approval for metal-on-metal resurfacing was obtained.[4,37] However, most surgeons do not have experience with resurfacing and do not believe there is a place for hip resurfacing procedures.[38]

All implant manufacturers indicated their metallurgy had improved, and the critical importance of proper component positioning was not emphasized initially. In fact, the large diameter of metal prostheses was thought to protect against dislocation even in instances of component malposition. Component position alone, however, does not fully explain the development of metallosis. There are patients who develop metallosis with ideally positioned components and some with poorly positioned components who do not develop metallosis. A study from The Mayo Clinic found no relationship between metallosis and component positioning.[32] In addition, reports of metallosis with the McKee-Farrar prostheses do not associate component position with metallosis. Radiographs from several reports do not support the conclusion that vertical component positioning was a problem with early metal-on-metal prostheses.[12,13,16,39–41]

Langton *et al.*[1] reviewed 4226 metal-on-metal resurfaced hips performed by three surgeons with a follow-up ranging from 10–142 months with the goal of determining the incidence of failure because of adverse reaction to metal debris. Resurfacing implants used were the Articular Surface Replacement (DePuy, Leeds, UK), the Birmingham Hip Resurfacing System (Smith & Nephew, Memphis, TN) and the Conserve Plus (Wright Medical Technology, Inc., Arlington, TN). There were 58 failures associated with metal debris, and the chromium concentrations in the failures were higher than in the control group ($P < 0.001$). The rate of failure for the Articular Surface Replacement was 9.8% at 5 years, compared with $< 1\%$ for the Conserve Plus at 5 years and 1.5% for the Birmingham Hip at 10 years.[1] Two of retrieved components showed little wear yet, overall, increased wear from the metal-on-metal bearing surfaces

was associated with an increased failure rate. They concluded that it is extremely difficult for surgeons to consistently place acetabular components precisely and there was considerable variation in the angle of inclination and anteversion.[1,42] Although there are patient variables such as pelvic tilt and intra-operative pelvic rotation, and obvious design variations among devices, the authors stated that surgeons must accept that some variables are beyond their control. The authors also thought that the arc of acetabular cover may be responsible for differences in development of metallosis between different prosthetic designs.[1] Also, the monobloc prosthesis typically used for resurfacing acetabular implants may deform on impaction and result in edge loading.[43]

## NOISE

All artificial joints make noise. Acoustical analyses of noise from metal-on-metal and ceramic-on-ceramic prostheses demonstrated that every implant tested produced substantial noise. Most often, the frequency of the noise generated is above the human audible range. Thinner acetabular shells produce lower frequency noise and when two very thin shells are used, such as with resurfacing, noise within the audible range is possible. Resurfaced hips with metallosis reliably produce an audible or palpable sense of noise or vibration.

Audible sounds from ceramic-on-ceramic hip prostheses have received considerable attention since 2005. Squeaking occurs in up to 10% of hips with ceramic-on-ceramic prostheses but rarely presents a clinical issue.[33,44] Squeaking also occurs with metal-on-metal hip prostheses in up to 10% of patients.[44] It is self-limited and rarely is of clinical concern. A clunking sound is much more common with metal-on-metal prostheses and occurs in up to 19.4% of patients in one report.[45] Clunking is more prevalent in the first several months after surgery but may continue. With hard-on-polyethylene joints, clicking is the sound most often reported.

The sounds coming from hard-on-hard bearing prostheses are produced by forced vibration. When loss of fluid film lubrication occurs with hard bearings, high levels of friction may result. Loss of fluid film lubrication may be caused by edge loading, impingement, third-body particles, bearing surface damage, or alteration in the joint fluid. Edge loading increases the coefficient of friction several fold.[39–41] Aspiration of the hip joint revealed ceramic particles in all patients with squeaking hips in a study of ceramic-on-ceramic hip prostheses.[33] Joint aspiration of metal-on-metal hips that have become progressively more noisy shows evidence of metal staining in almost every instance. The key issue with noise production from a metal-on-metal hip is its pattern over time. If the noise lessens or remains stable, the outcome is likely favorable. Noise that becomes more prominent is suggestive of metallosis. Clunking rather than squeaking is the important noise for a metal-on-metal hip. In the absence of metallosis, squeaking and other noise from joint implants generally follow a benign course.

The author has had success injecting squeaking hip joints with hyaluronic acid. With well-functioning, well-positioned components, two or three injections (16 mg each week) generally have been successful in substantially reducing or eliminating squeaking. Although there are no published reports of injecting hyaluronic acid into a resurfaced joint, there are more than 40 published studies describing the efficacy and safety of such injections into osteoarthritic joints.[46] Its use in medicine also includes treatment of wound healing problems, prevention of post-operative adhesions, urinary incontinence, ophthalmic surgery, tissue augmentation and engineering.

## EXCLUDING OTHER DIAGNOSES

Most patients with symptoms after metal-on-metal hip joint surgery do not have metallosis. Moreover, most patients who are given this diagnosis, even after revision surgery, do not have metallosis. Metal staining of the tissues, without noise and without a highly elevated cobalt level, does not warrant the serious diagnosis of metallosis. Careful laboratory analysis shows that many suspected cases of metallosis have been diagnosed incorrectly. The most common alternative diagnosis is failure of osseointegration of the acetabular component (Figures 3 and 4). It is more difficult to osseointegrate cobalt prostheses than titanium. Also, the large inner bearing diameter places high force on the implant and, secondarily, on the prosthesis-bone-interface. The standard one-piece cobalt prosthesis used for resurfacing cannot accept supplemental screw fixation, further compromising the security of acetabular component fixation.

Acetabular components that have not osseointegrated can be a source of pain; however, this often is difficult to detect radiographically, at least initially, before radiolucent areas appear. The initial press fit limits the amount of initial pain. Within a few months, pain from poor osseointegration may occur. The onset of this pain generally is earlier than the onset of pain from metallosis. A loose acetabular

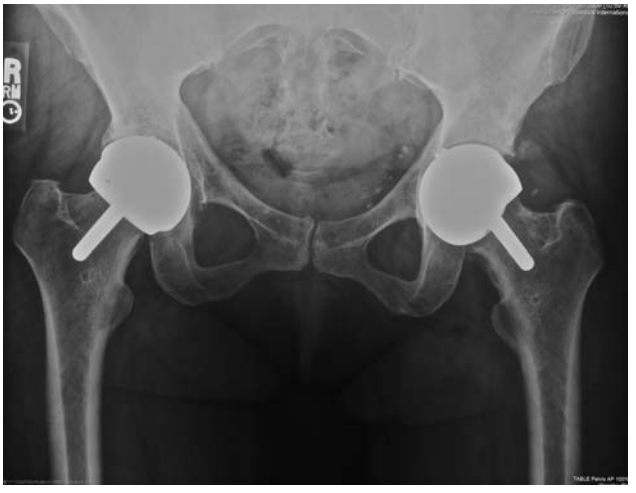

**FIGURE 3.** Anteroposterior radiograph of a 46-year-old woman who has undergone bilateral hip resurfacing surgery using Birmingham prostheses. On the right the outcome is successful but on the left, the hip is painful from failure of osseointegration, and there is a lucent line around the acetabular prosthesis.

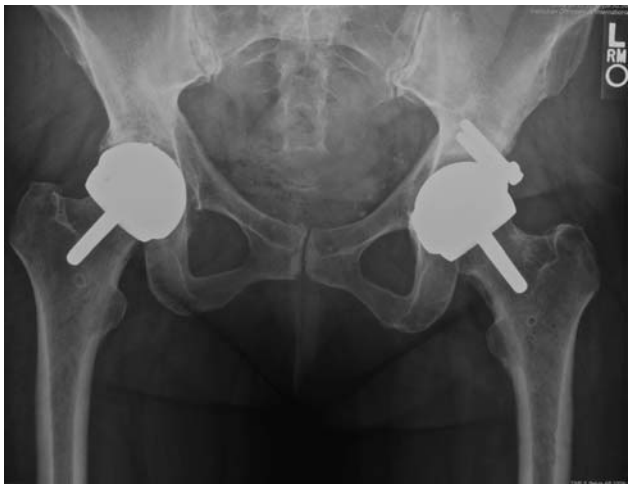

**FIGURE 4.** A revision of the left acetabular component has been performed using a dysplasia component with supplemental screw fixation.

component will elevate cobalt levels modestly. During joint aspiration, local anesthetic that is instilled into the joint can be helpful in establishing the diagnosis. Revision surgery is very successful for patients with failure of osseointegration.

Periprosthetic fractures, particularly of the femoral neck, can occur intra-operatively or postoperatively. These may be difficult to see with radiographs and require bone or CT scans to detect. Some of these fractures will heal with time but many require revision surgery. Infection, tendinitis, and heterotopic ossification can be discovered usually by examination, and each condition is quite treatable. Tendinitis is particularly common with resurfacing, as the joint is re-spaced during surgery, resulting in modest tendon lengthening. Some patients feel their operative limb is longer after resurfacing surgery. Typically, after 6–7 months patients no longer perceive a notable limb-length inequality.

Synovitis is common after joint implant surgery. Synovioctyes are capable of proliferative overgrowth and substantial effusions are common even in well-performing joint replacements. Great caution is necessary in interpreting the presence of effusions on MRI or CT scans after joint resurfacing or replacement.

## DIAGNOSIS OF METALLOSIS

The symptoms of metallosis include pain, a sense of instability, and increasing noise coming from the hip. The symptoms evolve over several months and are typically progressive. Metallosis has not been proven to occur earlier than 9 months postoperatively but symptoms always present within the first 4 years after surgery. Pain that remains or appears immediately after the recovery interval after surgery is not caused by metallosis. Up to 18% of patients with hip resurfacing experience groin pain after surgery but only 2–5% have metallosis.[47] Bartelt *et al.*[48] found the rate of postoperative groin pain to be 7% (15 of 217 patients) after total hip arthroplasty with conventional bearing surface and 15% (four of 26 patients) after metal-on-metal total hip arthroplasty. They noted that groin pain was more common among younger patients who also were more likely to have metal-on-metal bearing surfaces.

Several other causes for symptoms after metal-on-metal hip resurfacing require consideration. These include implant loosening, periprosthetic fracture, osteonecrosis, infection, tendinitis, impingement, and referred pain. Selective injections and advanced imaging can be helpful in discovering the cause of symptoms.

## TREATMENT OF METALLOSIS

There is no medical, physical, or nonoperative treatment for progressive metallosis. It is not possible to chelate the excess cobalt from either the joint or serum. Usually, once metallosis occurs, the tissue response continues and, thus, surgery would be necessary. In some cases, a small amount of metallosis does not progress, and surgery may not be necessary. With early diagnosis, almost all patients respond favorably to surgery. The surgical options must be tailored to the needs and desires of the patient rather than the surgeon.

Few surgeons are experienced in evaluating and treating patients with metallosis. Even fewer have the necessary extensive experience with resurfacing. If the initial outcome of the resurfacing procedure is favorable and the patient is young and active, the indications may remain for hip resurfacing.

## METAL-ON-METAL HIP RESURFACING REVISION

In most patients with metallosis, the hip resurfacing can be revised successfully, usually with an acetabular-only revision.[3] De Haan *et al.*[3] performed revision of metal-on-metal resurfaced hips in 42 patients, primarily because of acetabular cup malpositioning, associated metallosis, and increased serum ions. The authors reported excellent results in all patients who underwent an acetabular only revision, maintaining their resurfacing prosthesis. Four patients treated by conversion to total hip replacement using small diameter femoral head components had a post-revision dislocation and underwent another revision.

The author performs most revision procedures with primary resurfacing components using the same component size (Figures 5 and 6). Outside diameters 2–4 mm larger also are available, if necessary, to achieve a secure press fit. Peripheral screws can be beneficial if additional fixation is necessary. The components provided for patients with dysplasia can be used for this purpose (Figure 4). Because of the potential for superior osseointegration, the author now uses a two-piece titanium backed with a cobalt insert for some revisions and certain difficult primary procedures (R3 Acetabular System, Smith & Nephew, Memphis, TN; Figure 7). In the author's experience with revision resurfacing, patients reported a shorter recovery interval than with the index procedure. For an experienced resurfacing revision surgeon, the procedure can be completed readily. The original position for the resurfacing is avoided, and a better position for the new acetabular component is more apparent. Often it is possible to see where the original component did not match the prepared bone. The original

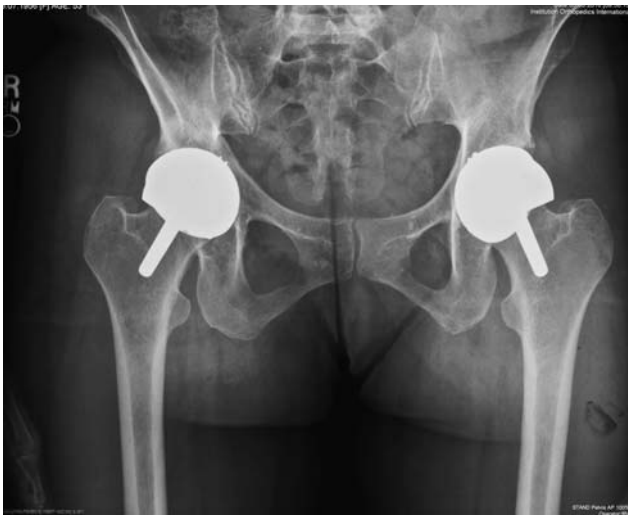

**FIGURE 5.** Anteroposterior radiograph of a 45-year-old woman who underwent bilateral hip resurfacing surgery for dysplasia. On the right the outcome was successful, but on the left she developed metallosis. The acetabular component has a vertical orientation.

component migrated either at the time of impaction or later. Unlike revision total hip replacement, the results of revision resurfacing do not result in any reduction in function or increase in complications compared with primary procedures. Ninety-five percent of the author's revision procedures have been successful.

## ACETABULAR COMPONENT POSITIONING CHALLENGES

It is much more difficult to accurately place and secure an acetabular component during resurfacing surgery as compared with total hip replacement.[3] Gaining access to the

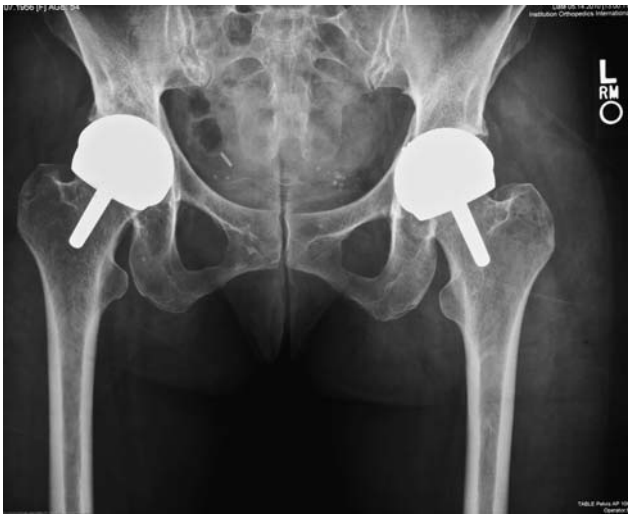


**FIGURE 6.** A revision of the left acetabular component of patient in Figure 5 to a more horizontal position was performed and the outcome was successful.

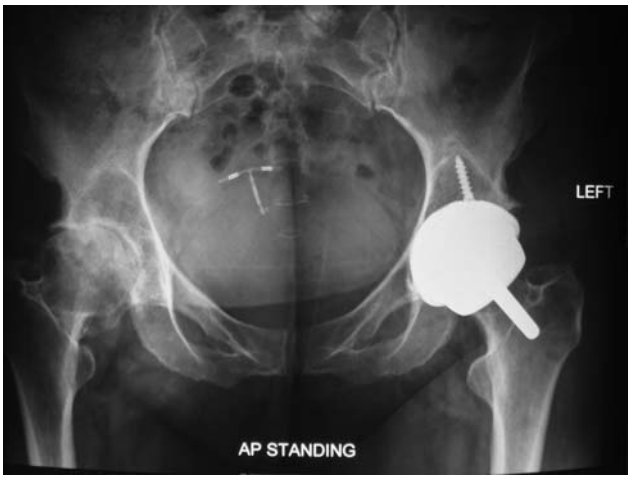


**FIGURE 7.** The R3 two-piece titanium-backed cobalt bearing prosthesis has been used to provide a successful revision of the hip resurfacing.

acetabulum is more difficult because of the retained femoral head and neck. Most patients presenting for resurfacing have an abnormally shaped, dysplastic native acetabulum. The presenting acetabulum is oriented vertically, and attempts to preserve the bone during preparation tend to lead to increased anteversion and vertical orientation. It is very unusual to see an acetabular component positioned more vertical than the native acetabulum. Also, the acetabular bone is hard and sclerotic in the areas where there has been uneven weight bearing. Resurfacing acetabular components are driven into the acetabular bone; the harder bone in some areas and softer bone in others tend to tilt the acetabular component at the time of impaction or with later load bearing. The rigid monobloc resurfacing acetabular components are difficult to position.[32] The radiographic appearance of an acetabular component is a combination of version and abduction. In rough terms, each degree of increased anteversion becomes a degree of increased vertical acetabular orientation. In recent reports, only 40% of resurfacing acetabular prostheses are positioned ideally even in the hands of experienced hip surgeons.[49]

## REVISIONS WITH POLYETHYLENE

Some patients who have developed metallosis are concerned about continuing with a metal-on-metal bearing surface. Women and patients with smaller femoral head sized components present the greatest concerns. If a woman or smaller patient remains an appropriate candidate for resurfacing, revision of the acetabular component to polyethylene often is possible. A standard two-piece, titanium-backed component with a large diameter cross-linked polyethylene inner bearing is used (Stryker, Mahwah, NJ and Endotec, Inc., Orlando, FL; Figures 8–10). Alternatively, using a cemented all-polyethylene acetabular prosthesis (BioPro, Port Huron, MI) with or without a titanium acetabular cage is possible.[35]

Placement of these components is similar to conventional total hip replacement. The results of these procedures are favorable for most patients, and recovery is more rapid as

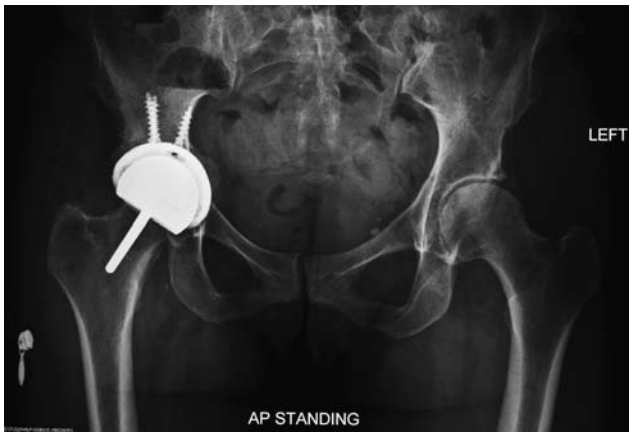


**FIGURE 8.** Anteroposterior radiograph of a 51-year-old woman who underwent an acetabular revision of her resurfacing prosthesis using a two-piece titanium and polyethylene prosthesis.

compared with the initial resurfacing procedure and revision to total hip replacement. Concerns remain about the long-term durability of polyethylene, particularly in the larger and thinner sizes.[35,36,50,51] Cemented acetabular components may loosen over time, but the longevity with this solution is often many years.[35,36,50]

When presented the option of polyethylene resurfacing, patients often question the durability of this material. The wear simulator data available at this time suggest that even with the larger diameter femoral components, 10 or more years of useful implant life are possible. Most patients requiring resurfacing are young and will need more than 10 years of use from their prosthesis. If wear-through occurs, a straightforward revision to another polyethylene liner

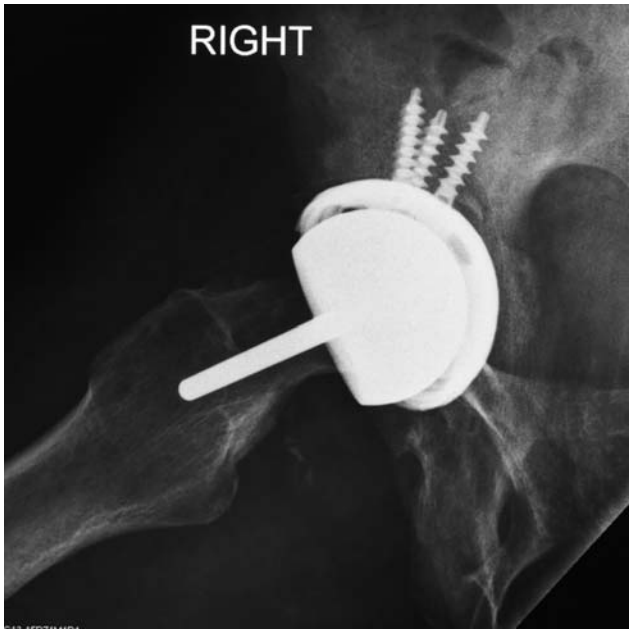


**FIGURE 9.** Lateral radiograph of patient in Figure 8 shows the availability of dome screw adjunctive fixation in the compromised acetabular bone.

**FIGURE 10.** Photograph shows a currently available resurfacing prosthesis with a titanium-backed polyethylene acetabular-bearing surface as an alternative to metal-on-metal.

should be possible. Also, surveys have shown consistently that given the trade-off between prosthesis survivorship and function, patients choose function. Therefore, polyethylene resurfacing remains a reasonable option for many patients.

## ALTERNATIVES TO COBALT PROSTHESES

It is possible to perform hip resurfacing surgery using a nitrated titanium femoral prosthesis with a polyethylene acetabular component, but published long-term data with this option are not readily available (Figure 10). From 1995 until 2005, the author used a ceramic femoral prosthesis with a cemented polyethylene or two-piece metal-backed polyethylene acetabulum with satisfactory outcomes. The FDA reclassified the femoral device, and additional testing will be required for continued use.[36,52]

Poly-ether-ether-ketone (PEEK) is used widely in orthopaedic applications and has been used as a bearing surface for joint replacement in Italy. Pace *et al.*[53] analyzed the technical and histologic properties of a PEEK composite alumina-bearing liner that was removed 28 months after implantation because of a post-traumatic infection. They found a low amount of particles from the PEEK composite in the periprosthetic tissue. Results from an ongoing multicenter study of the safety and efficacy of a PEEK liner are forthcoming. PEEK may become a candidate material for resurfacing.

## REVISION TO TOTAL HIP REPLACEMENT

Conversion to total hip replacement is performed by placing a two-piece, metal-backed, high-density polyethylene acetabular component and a stemmed femur. The metal chosen customarily for both components is titanium. For this option, it is important that the surgeon has substantial experience with revising resurfacing prostheses. It is the author's experience that the acetabular component of the resurfacing prosthesis can be removed easily, but the femur rarely is loose and it must be removed very carefully to

preserve the surrounding bone in the femoral neck. Broaching the femur can be very challenging. The former channel for the stem of the resurfacing component must be appreciated and bypassed carefully.

Instability may be a concern in performing a revision from a resurfacing prosthesis to a total hip prosthesis. The reasons for these concerns are multifactorial. The revised hip will have a smaller femoral head diameter than the resurfacing. Also, there has been a more extensive capsulectomy performed as part of the resurfacing.[38] In addition, the patient has been accustomed to the greater security of a resurfaced hip and may remain highly active. Using a relatively large ball diameter and very careful technique are recommended. Often a femoral head diameter of 40 mm or in some instances 44 mm is possible. If the acetabulum is secure, we recommend revision of only the femoral component using a dual-mobility prosthesis to preserve the natural femoral head size. Close follow-up of patients is recommended if only smaller diameter components are used. To avoid further compromise to the soft tissues, the same surgical approach as used for the resurfacing procedure is recommended.

## CONCLUSION

In summary, some patients will develop metallosis after hip resurfacing surgery. A careful clinical history of pain and an increased sense of noise are the characteristic symptoms. If elevated serum or joint cobalt levels are found, revision surgery usually is necessary. With early diagnosis, careful surgical planning and operative technique, outcomes usually are satisfactory.

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