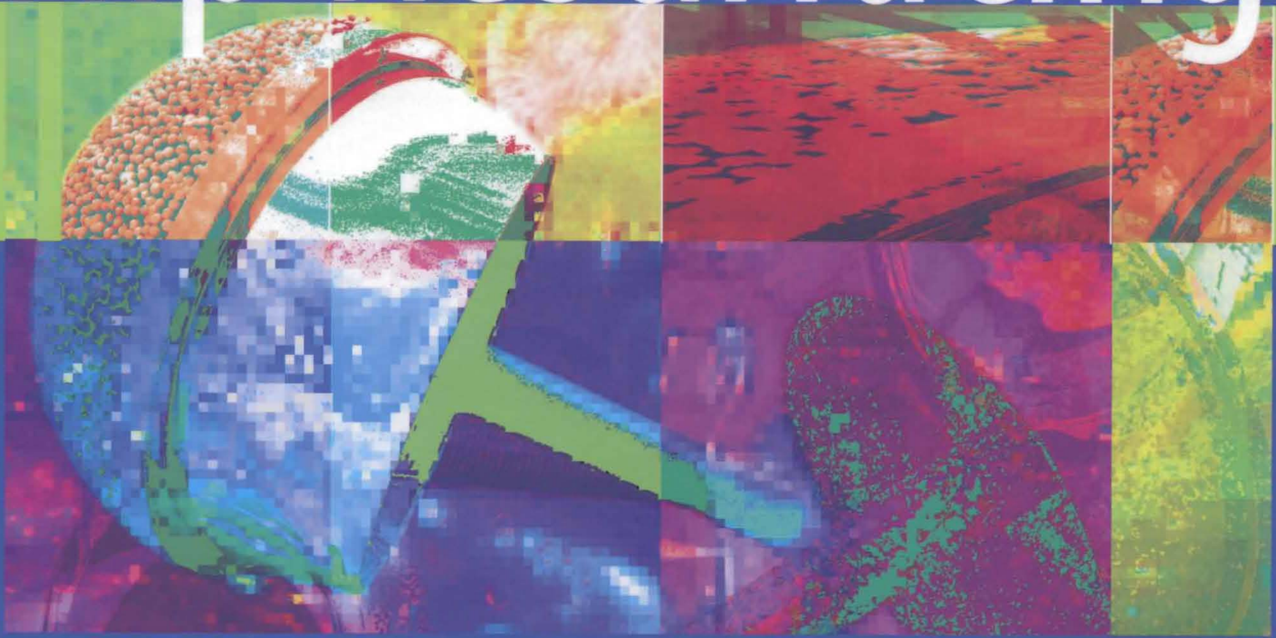
Derek McMinn *Editor*

Modern Hip Resurfacing



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titanium to the cup (see Chapter 6). The results of the McMinn 1996 started to dip at 5.5 years and produced an 86% survivorship at 10 years in addition to a 20% radiographic failure rate in unrevised patients. The regulatory authorities have made their decision on very short-term clinical data. Would a well-informed surgeon, free from the shackles of financial interest, view the evidence differently?

The trend over the past few years is that all small implant companies are bought by large U.S. corporations, who in turn amalgamate. Who is served well by this process? The shareholders of the corporations and employees with share options and bonuses are the beneficiaries. Distributors do well, often receiving commissions of 20% on sales. The corporations provide lubrication so the system works for them, with consultancy contracts for surgeons, royalty payments, and institutional financial support being commonplace to ensure brand loyalty. The costs associated with all this are enormous. It can only be afforded because of the fantastic profit margins available in the United States. As explained earlier, implant design is by committee, with little prospect of better implants resulting. Most of this process is intended to give the illusion of a "high tech" company with a major interest in design and development. That is why the spin doctors are involved in design teams. There is no intention of developing a "new" implant; that would be a regulatory and financial nightmare. In reality, surgeons have to cope with a smaller product range. When amalgamation of corporations happens, large numbers of lesser-known niche products are abandoned, and surgeons are forced to use the limited range of core products. Corporations ensure that their design teams have an international feel, but in effect the overseas surgeons are "political" appointees and are mere paid pawns in the process. How will the little-known surgeon working in some far-off land with a great idea for a new product get on in this system? He doesn't stand a chance. Ultimately, the losers will be patients, with potentially great ideas never tested. If for any reason the profit margins in the United States came down to the level of the rest of the world, there would be a serious meltdown of many corporations. A clampdown on lubrication would only increase company profits. The really serious problem would be third-party payers developing a taste for European-priced products, or worse still a cap on reimbursement for implants, like the system in France. I believe the system will melt down, and I predict chaos in large corporations with major "corrections" necessary. Small companies will come back into play, and this will be good for the "driven" designer surgeons irrespective of geographic location and ultimately good for genuine product development and patients.

The next puzzle relates to the history of metal on metal bearings, in particular, the history of metal on metal bearings in hip resurfacing. In Chapter 1, I outlined the history of hip resurfacing and metal on metal bearings from a very personal viewpoint and within my own experience. There have been two volumes of *Clinical Orthopaedics* that deserve attention. The first was in 1978, which attempted to review all the art at the time. This volume concentrated on hip resurfacing. The second was in 1996, and this reviewed the reintroduction of metal on metal articulations and attempted to cover the history of metal on metal bearings. As I shall now show, both of these collector items have a very significant omission, and this omission has also been made in much of the history of this subject that has been written.

At an American Academy of orthopaedic surgeons' conference in 2001, I had a long meeting with Charles Townley (Fig. 31.4). What an interesting and innovative surgeon! He designed and implanted the first condylar total knee replacement. He had done much work on conservative hip arthroplasty, and it was on this subject that I wanted to get his views. At the time of our meeting, he was against metal on metal articulations, and he tried to encourage me away from metal on metal as a bearing material for my resurfacing. He was very focused (another one!) on frictional torque, and he believed that the frictional torque and wear of metal on metal articulations with the resultant ion exposure was not good. He was trying to encourage me down the route of using polyurethane because, as we all know, the theoretical advantages of a soft bearing with genuine fluid film lubrication are considerable. I found our conversation most stimulating, but he did reveal one fact at the time. He said he had done some metal on metal hip resurfacings but again he advised me against this. I pursued my quest for information on exactly what Townley had done, and now we know. Dr. Jim Pritchett has followed up a large cohort of Townley's and his own cases, and you will see that Townley's definition of "some" is understated. He performed 133 metal on metal resurfacings with a mean follow-up of 26 years and a zero failure rate.

If I get any credit for the introduction of modern metal on metal hip resurfacing, then Charles Townley deserves huge credit for having made this operation work many years ago.

Sadly, Charles Townley died recently, and I am going to give the last words in this book to Dr. Jim Pritchett so that the

FIG. 31.4. Charles Townley at approximately 58 years (1916–2006).

history books can record correctly the tremendous work of a great innovator and show conclusively that metal on metal hip resurfacing is not new and can be remarkably successful.

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Conservative total Articular Replacement Arthroplasty: Minimum 20-Year Follow-Up

James W. Pritchett

Abstract Hip joint resurfacing is an attractive concept because it preserves rather than removes the femoral head and neck and may provide better functioning. We report the first long-term follow-up on total hip resurfacing. A total of 445 patients (561 hips) were followed for a minimum of 20 years or until death; only 23 patients were lost to follow-up. Patients received a metal femoral prosthesis with a small curved stem. Three types of acetabular reconstruction were used: (i) cemented polyurethane, (ii) metal on metal, and (iii) polyethylene secured with cement or used as the liner of a two-piece porous-coated implant. Long-term results were favorable with the metal on metal combination only. None of the 121 patients (133 hips) who received a metal on metal articulation experienced failure. The failure rate with polyurethane was 100%, and the failure rate with cemented polyethylene was 41%. Thus, although hip resurfacing using a metal on metal articulation with a curved-stemmed femoral component is a technically demanding procedure, the prosthesis is durable, and the clinical outcome is generally favorable.

Introduction

Hip joint resurfacing offers several functional benefits over total hip replacement: the size of the femoral head and neck remains close to normal, and the resurfaced hip is stable and capable of an excellent range of motion, proprioceptive feedback from the remaining metaphyseal bone may be preserved, and the joint retains a greater degree of normal biomechanical function [1,2,9,18,28,30,31]. It also offers several procedural benefits: postoperative infection is usually resolved easily because only a limited amount of implanted material is used; it is less invasive than is conventional hip replacement because it does not involve decapitation of the femur; and it results in less blood loss, is more stable, and rehabilitates more easily [19,30,31]. The disadvantages of this procedure include the possibility of femoral neck fracture or collapse of the femoral head due to osteonecrosis. Additionally, it is a demanding procedure that requires both anterior and posterior dislocation of the joint.

The first total hip resurfacing arthroplasty was developed by Charnley in 1951 using a polytetrafluoroethylene on polytetrafluoroethylene (Teflon or Fluon) bearing [10]. The procedure failed due to osteonecrosis of the femoral head. In the 1970s, hip resurfacing was popular in several centers in Europe, Japan, England, and the United States. Initial promising results gave way to unacceptable failure rates, however, owing to acetabular loosening, wear, or both. Less commonly, femoral neck fracture, osteonecrosis, or loosening of the femoral component occurred [11,15,24]. Interestingly, none of the other resurfacing designs used a femoral stem.

Resurfacing was largely abandoned again until the 1990s when it was resurrected for the same reasons that made it attractive initially: patients want an active lifestyle, they want to keep their bone, and they don't want to worry about having a failed intramedullary, stem-supported hip prosthesis [2,9,28].

The purpose of this report is to evaluate long-term results of a hip joint resurfacing prosthesis and comment on what we are doing today.

Materials and Methods

Patient Population

We evaluated 561 total hip joint resurfacing procedures that were performed in 445 private practice patients from 1960 to 1987. None of the patients had undergone a prior implant arthroplasty procedure, although a few had been treated previously for a dislocated hip or fracture. The underlying diagnosis was osteoarthritis in 334 patients (75%); osteonecrosis in 44 (10%); posttraumatic arthritis in 31 (7%); inflammatory arthritis in 18 (4%); and developmental dysplasia in 18 (4%) patients.

The patient population consisted of 218 women and 227 men with a mean body weight of 71 and 82 kg, respectively (range, 50–107 kg). The mean age was 52 years (range, 30–74 years) with 97 patients aged 30 to 40 years, 118 aged 40 to 50 years, 109 patients aged 50 to 60 years, 100 aged 60 to 70 years, and 21 patients aged 70 to 74 years. Institutional review board approval was obtained for this study.

Surgical Procedure and Implants

Each surgical procedure was carried out through an anterolateral approach without trochanteric osteotomy. The hip was dislocated anteriorly, and the femur was prepared. The femoral head was downsized when possible using great care not to notch the femoral neck. The zenith of the femoral head was removed at an approximate 140-degree angle to the femur, and all at-risk bone was removed. Cylinder and chamfer cutters were used to complete the preparation of the femoral head [26]. Whenever possible, the femoral stem was placed parallel to the medial trabecular system [6,11,23]. Prostheses were placed using an interference fit, cemented, or porous-coated technique.

The type of prosthesis varied with the time at which the procedure was done. In the earliest procedures, the acetabular surface used was polyurethane. This polymer was prepared by mixing the prepolymer with resin and the catalyst at the time of surgery and shaped to the femoral prosthesis. Polyurethane served as both the anchoring cement for the femoral side and as the articular replacement and cement for the acetabulum. Although it is a "plastic," it had a fairly rough finish. Metal on metal implants were made of cobalt chromium (Depuy Co., Warsaw, IN; Howmedica Co., Rutherford, NJ; Zimmer Co., Warsaw, IN) (Figs. 31.5 and 31.6).

They were placed without cement on the acetabular side and with or without cement on the femoral side. The length of the stem varied from 27 to 165 mm with longer stems used more commonly in the earlier cases.

Polyethylene, which became available in the 1970s, was initially used in a thickness of 4.5 mm, which was later increased to 6.0 mm and cemented in place using polymethylmethacrylate. The two-piece metal-polyethylene component was porous-coated with a coxcomb fin for adjunctive fixation (Fig. 31.7).

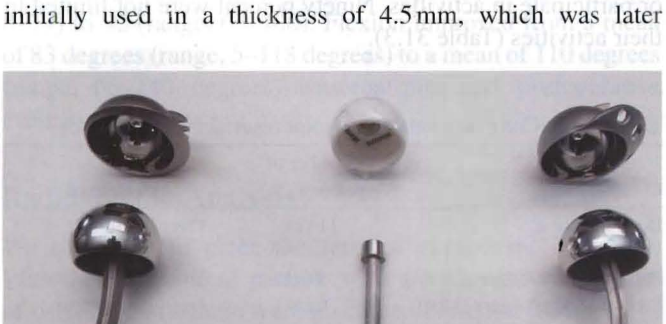

FIG. 31.5. Photograph of the curved stemmed metal on metal and ceramic surface replacements.

FIG. 31.6. Radiograph of cementless metal-on-metal prothesis.

Patient Follow-Up

Patients were followed prospectively and were asked to return at 1 year, 2 years, 5 years, and every 5 years thereafter. When

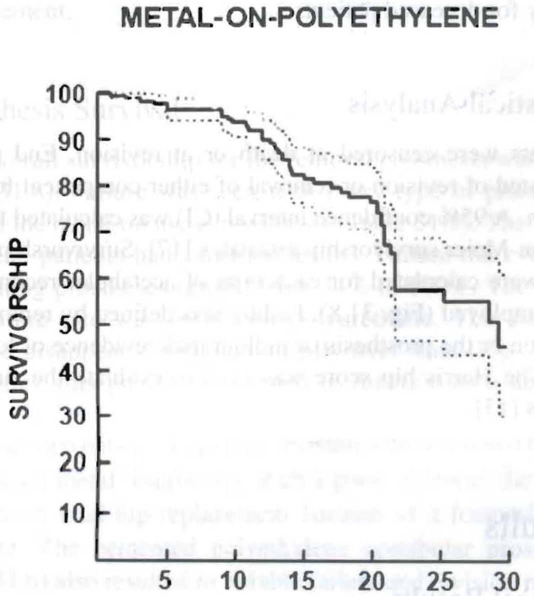

FIG. 31.7. Radiograph of cemented polyethylene cup on one side and a cementless acetabular prosthesis on the other.

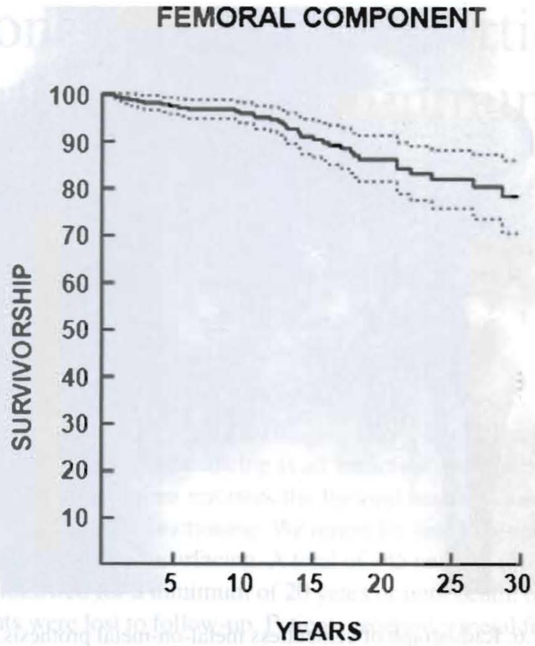

FIG. 31.8. Kaplan-Meier survivorship curve for the femoral component.

this was not possible, they were asked to answer a written questionnaire or were contacted by telephone and interviewed using a standard telephone questionnaire. Patients were queried specifically about the need for additional surgery on their hip. If it had been required, they were asked to provide information about that procedure. The date of death was obtained by direct communication with the family. Information about the patient's hip function was obtained from the family for deceased patients.

Statistical Analysis

Patients were censored at death or at revision. End points consisted of revision or removal of either component for any reason. A 95% confidence interval (CI) was calculated for the Kaplan-Meier survivorship estimates [17]. Survivorship analyses were calculated for each type of acetabular reconstruction employed (Fig. 31.8). Failure was defined by removal or revision or the prosthesis or radiographic evidence of loosening. The Harris hip score was used to evaluate the surgical results [13].

Results

Clinical Results

Ninety-five percent of patients were followed until death or at least 20 years. By 2007, 374 (84%) of the 445 patients had died. The mean age at time of death was 80 years (range, 58–99 years), and the mean survival time from surgery to the time of death was 22 years. The remaining 71 patients (16%) had been followed an average of 27 years (Table 31.1). The most common complications seen at any time during the follow-up period included deep infection, dislocation, and periprosthetic fracture. The periprosthetic fractures occurred sporadically anytime after the surgical procedure from 6 months to 36 years later. Less frequently, intraoperative fracture and nerve palsy occurred (Table 31.2).

Medical complications of various types occurred in approximately 5% of patients. In 21 procedures, technical difficulties—including poor exposure, change in intraoperative alignment and poor impaction of the cup or stem—were associated with obesity.

Patients were assessed for pain and function 2 years after the resurfacing procedure. Most patients experienced no pain, and only four (<1%) experienced severe pain. Of the 445 assessed for postsurgical activity, a third participated in athletics or strenuous work and only 22 (5%) did not work or participate in activities. Ninety percent were not limited in their activities (Table 31.3).

TABLE 31.1. Survivorship among patients treated with hip joint resurfacing.

	Number of patients (%)	Mean age of survivors (range) (years)
Overall survivorship		
Survivorship until death	374 (84)	80 (58–99)
<5 years	19 (5)	
5–9 years	24 (6)	
10–19 years	54 (14)	
20–30 years	166 (45)	
>30 years	111 (30)	
Patients alive at follow-up	71 (16)	75 (53–94)
Survival periods		
20–30 years	51 (72)	
30–40 years	18 (25)	
40 years	2 (3)	

TABLE 31.2. Complications of hip joint resurfacing procedures.

Complications	Number of patients (%)	Comments
Deep infection	11 (2)	Over lifetime of prosthesis
Dislocation	5 (<1)	
Periprosthetic fracture (hips)	6 (>1)	Inter- and subtro chanteric
Femoral neck fractures	10 (1.7)	
Intraoperative femoral neck fracture	1	Converted to total hip replacement
Femoral nerve palsy	2	Both patients recovered
Sciatic palsy	5 (<1)	Recovery: 2 full; 2 partial; 1 limited due to peroneal and tibial involvement

TABLE 31.3. Functional results of hip joint resurfacing.

Pain	Number of patients (%)	Comments
Assessed 2 years after procedure		
No pain	459 (82)	
Slight pain	86 (15)	
Moderate pain	12 (2)	
Severe pain	4 (<1)	
Function: Postsurgical activity (Assessed 2 years after procedure in 445 patients)		
Highly active	147 (33)	Strenuous sports or job
Active and no limitations necessary	254 (57)	
Moderately active	22 (5)	
Inactive	22 (5)	
Patient satisfaction		
Satisfied with outcome	427 (96)	
Dissatisfied with outcome	18 (4)	Nine patients were dissatisfied because of a limp or weakness. Nine patients were dissatisfied because of pain.

TABLE 31.4. Radiographic findings after hip joint resurfacing.

Radiographic finding	Number of hips (%)	Comments
Femoral component	28 (5)	>5 degrees more varus postoperatively measured vs. medical trabecular system
Acetabular component malpositioned	17 (4)	Includes 11 with hip resurfacing failure
Acetabular and femoral components malpositioned	6 (1)	Includes 3 with hip resurfacing failure
Notched femoral neck	11 (2)	Includes 3 with a femoral neck fracture
Femoral component incompletely seated	2 (<1)	Includes 1 with hip resurfacing failure

Most patients reported satisfaction with their procedure (Table 31.3). However, 32 of 44 (73%) patients with osteonecrosis experienced prosthesis failure (mean time to failure 7 years). There were 27 (6%) patients who had undergone a resurfacing procedure on one side and a conventional total hip replacement on the other. All indicated that the hip that had undergone resurfacing was the "better hip." There was no difference in the outcomes in this series based on the gender of the patient.

The mean peak Harris Hip score improved from 57 (range, 8–79) to 92 (range, 63–100). Flexion improved from a mean of 83 degrees (range, 5–118 degrees) to a mean of 110 degrees (range, 65–140 degrees) between pre- and postoperative evaluations.

Radiographic Analysis

We attempted to place the femoral component in valgus. With the exception of patients with a preoperative diagnosis of osteonecrosis, there were no cases of femoral loosening or fracture when the femoral component was placed in valgus. Radiography revealed that in 28 hips (5%), the femoral component was in greater than 5 degrees more varus postoperatively than preoperatively compared with the medial trabecular system. It also revealed in some instances: malpositioned acetabular components; malpositioning of both the femoral and acetabular components; notched femoral necks; and incompletely seated femoral components (Table 31.4).

There was no difference in outcome based on the length the femoral stem.

Revision of the Resurfacing Prosthesis

All but two of the 141 revisions procedures involved a metal on polyethylene articulation; two involved a metal-on-polyurethane prosthesis. None of the metal-on-metal prostheses required revision (Table 31.5).

Both components were removed, and a new resurfacing prosthesis was inserted in two patients. The acetabular prosthesis alone was revised in 22 hips. The remaining 117 hips requiring revision were converted to a conventional total hip replacement.

Prosthesis Survival

The overall survivorship for the femoral prosthesis was 84% (Fig. 31.8). Failure was seen with every type of prosthesis except the metal on metal prosthesis (Table 31.5). The metal on metal patients had excellent results. Failure rates for the remaining prostheses ranged from 34% to 100%. The highest failure rate was seen with polyurethane. This bearing surface disappeared radiographically over time (Fig. 31.9); thereafter, this prosthesis seemed to function as a hemiarthroplasty.

Of the two patients requiring revision, one was converted to a metal on metal resurfacing, with a good outcome; the other underwent total hip replacement because of a femoral neck fracture. The cemented polyethylene acetabular prosthesis (Fig. 31.6) also resulted in notable failure and revision rates.

Fifteen patients received a two-piece cementless acetabular prosthesis in one hip and a cemented polyethylene in the other (Fig. 31.6). These patients also experienced notable failure rates (Table 31.5).

TABLE 31.5. Revisions of hip joint resurfacing prostheses.

	Type of prosthesis			
	Metal on polyurethane	Metal on metal	Metal on cemented polyethylene	Metal on two-piece cementless with polyethylene
Revision needed	2	0	105	34
Patients/hips	24/26	121/133	222/282	78/120
Mean follow-up, years (range)	24 (20–31)	26 (20–41)	25 (20–31)	21 (20–22)
Patients alive at follow-up	0	0	41	30
Patients lost to follow-up	0	2	15	6
Prosthesis failure rate	100%	0%	41%	34%
	Reason for failure			
More than one reason present in some patients	• Polyurethane wear (26) • Femoral neck fracture (1)	• N/A	• Loosening of acetabulum (76) • Polyethylene wear (30) • Loosening of femoral prosthesis (5) • Femoral neck fracture (6)	• Polyethylene wear (27) • Component loosening with migration (11) • Femoral neck fracture (3)

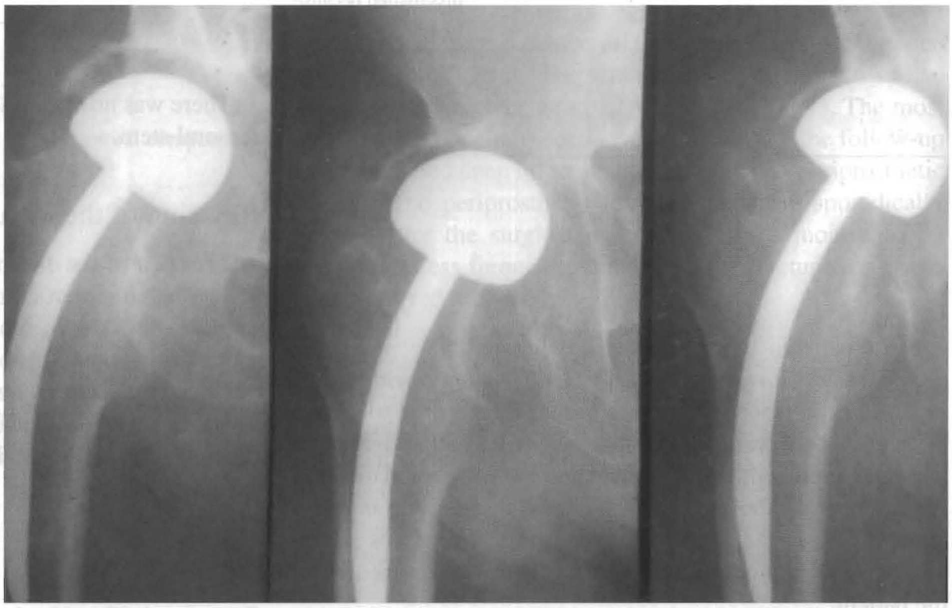

FIG. 31.9. Radiograph of a polyurethane acetabular resurfacing disappearing over time.

Discussion

To determine survivorship over a long period of time, we followed a large series of total hip resurfacing procedures. By following the patients for a minimum of 20 years or until death, we were able to determine their lifetime risk of failure. The high rate of follow-up and large number of patients followed until death suggests the survivorship estimates are valid.

Exposing and positioning the acetabular component with the femoral head in the way is technically difficult, and the preparation of the femoral head is demanding. The survivorship data in this series show more failures in the early years when compared with conventional hip replacement [34]. Failure resulted from unsatisfactory component positioning, loosening, and wear through of early acetabular resurfacing choices.

Complications that can occur with hip resurfacing include dislocation, postsurgical infection, nerve palsy, and fracture. Dislocations are much less common with resurfacing than with conventional replacement, in part as a result of the larger head size with resurfacing, but also because of superior proprioception compared to total hip replacement. The anterior approach was used in this series and may also enhance stability, but we and others now use the posterior approach with very few dislocations [2,9,28]. The few infections that occurred were easily treated because of the minimal penetration of the prosthesis into the medullary space.

Femoral neck fracture is actually a rare complication after hip resurfacing [2,9,25,28]. Periprosthetic fractures including the femoral neck do occur after hip resurfacing but at a similar rate as periprosthetic fractures with conventional hip arthroplasty [3]. The rate of femoral fracture and loosening was low in all age groups in this series. This was in spite of the effort made to downsize the femoral head that resulted in femoral neck notching in some cases. The low fracture rate even in

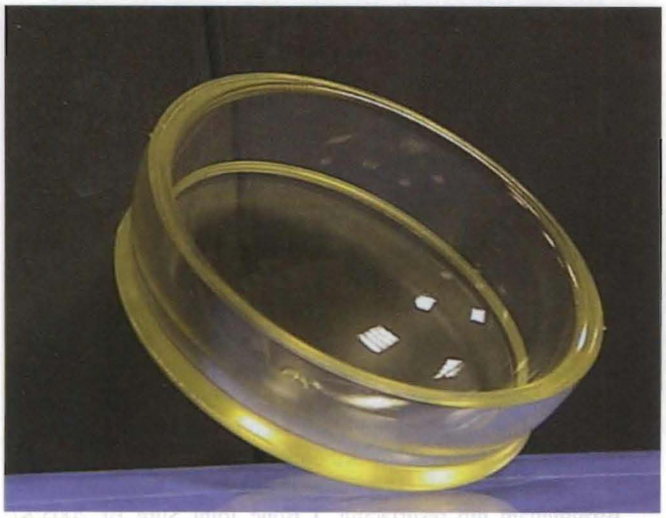

FIG. 31.10. Picture of flexible polyurethane acetabular component.

older individuals is attributed to valgus femoral component positioning. The loading forces on the femoral stem are optimal when they run parallel to the medial trabecular system with the femoral head perpendicular to it, and anatomic studies have shown that the medial trabecular system provides strength to the femoral neck. By contrast, varus positioning increases the tensile stress on the superior cortex, increases the medial compressive torque, and allows shear stress to develop at the prosthesis neck junction [16,24].

Most early resurfacing implants involved hemispherical preparation of the femoral head followed by placement of a hemispherical femoral implant; unfortunately, shear often resulted in loosening of these implants. These implants also did not have a femoral stem [11,15,24,32]. Several attempts have been made over the years to improve resurfacing implants: Gerard used a metal on metal prosthesis but did not fix the acetabular component to the pelvis; Mueller also performed metal on metal resurfacing procedures [12,21]. In this series, we used a prosthesis originally known as "cup-stem arthroplasty," in which the hemisphere was replaced by a flat-topped cylinder. The technique used to place this implant excised at-risk bone in the femoral head, and this may have contributed to the low failure rate. The head design provides compressive resistance stability, and a short, curved stem on the prosthesis adds varus stability without stress relieving the proximal femur [8,20,26,27]. A femoral stem is important in achieving satisfactory long-term results.

The difficulties with hip resurfacing in this series were primarily on the acetabular side. Well-performed femoral resurfacing rarely fails over time; this was true when an interference press-fit technique was used when neither cement nor porous coating was yet available. Early procedures involved the use of materials that did not provide an appropriate acetabular surface. Charnley used polytetrafluoroethylene in the first hip resurfacing procedure, and it failed [4,5]. In this series, polyurethane failed every time. However, polyurethane does not cause an osteolytic reaction; as a result, patients functioned generally well as it wore away. They had some pain, and radiographs of the hip joint looked as though a hemiarthroplasty had been performed (Fig. 31.9). Fortunately, the crude polyurethane used in the early days has now been reformulated. Our new polyurethane has very little wear, it is flexible, and the wear debris does not cause osteolysis. We are able to use our polyurethane cups with or without metal backing and with either a metal or ceramic femoral component (Fig. 31.10).

Another contributor to resurfacing arthroplasty failure in this series (and in others) was the use of cemented polyethylene acetabular components that loosened and wore through, often resulting in osteolysis [1,11,14,15,24]. Metal-backed cemented polyethylene sockets were not used in this series, but others have reported prosthesis failure when they were used in such procedures [22,29]. Our cross-linked polyethylene acetabular component worked better; particularly when used with a ceramic femoral prosthesis (Fig. 31.5).

Theoretically, avoiding a hard on hard joint surface should be advantageous. The strain distribution on the acetabular aspect is adversely affected by the stiffness of a metal component [16,33]. In this study, the use of polyethylene required removing an excessive amount of acetabular bone or insertion of a thin implant that would be prone to wear or loosening. Actually, more patients have the appropriate geometry for hip resurfacing with metal on metal implants than for other implants, because metal on metal devices make it is possible to couple thin heads of large diameter.

In our series, the metal on metal prosthesis was the second type of prosthesis tried. Metal on metal prostheses fell out of favor when polyethylene became available, until the drawbacks of polyethylene became apparent. Today, metal on metal is once again the most popular option. Patients who have received prostheses made of the newer metals do not yet have long-term follow-up. These devices, which require a porous-coated acetabulum and straight femoral stem, are similar to the metal on metal prostheses described in this report. The superior articulating characteristics of the metal surfaces available today suggest that excellent longevity can be expected [2,9,28]. Ions are released from the surface of these devices; the significance of this phenomenon remains unknown. However, no difficulties related to this issue were identified in this study [7].

Conclusion

Hip resurfacing is a technically demanding procedure, but it can be successful, and the results can be satisfying for the patient. Hip resurfacing requires good bone quality, and restitution of significant preoperative limb length inequality is not possible. Moreover, some acetabular deformities cannot be addressed. However, it is an attractive option for a young patient fearing a potentially difficult future revision.

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James,

At long last we have the book! Many thanks indeed for the final chapter – just shows – nothing is new. I like the book, hopefully you will enjoy it too.

Derek.

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