Metal-on-metal resurfacing of the hip in patients under the age of 55 years with osteoarthritis

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The results of conventional hip replacement in young patients with osteoarthritis have not been encouraging even with improvements in the techniques of fixation and in the bearing surfaces. Modern metal-on-metal hip resurfacing was introduced as a less invasive method of joint reconstruction for this particular group.

This is a series of 446 hip resurfacings (384 patients) performed by one of the authors (DJWM) using cemented femoral components and hydroxyapatite-coated uncemented acetabular components with a maximum follow-up of 8.2 years (mean 3.3). Their survival rate, Oxford hip scores and activity levels are reviewed.

Six patients died due to unrelated causes. There was one revision (0.02%) out of 440 hips. The mean Oxford score of the surviving 439 hips is 13.5. None of the patients were told to change their activities at work or leisure; 31% of the men with unilateral resurfacings and 28% with bilateral resurfacings were involved in jobs that they considered heavy or moderately heavy; 92% of men with unilateral hip resurfacings and 87% of the whole group participate in leisure-time sporting activity.

The extremely low rate of failure in spite of the resumption of high level occupational and leisure activities provides early evidence of the suitability of this procedure for young and active patients with arthritis.

Joint replacement may provide a dramatic improvement in the quality of life of patients with end-stage arthritis of the hip. However, those who are young and active still pose a formidable problem, as conventional hip arthroplasty does not provide a lasting solution to their needs.[1-3] Charnley[4] recognised early that hip replacement would have a high failure rate in young patients and in those with no 'built-in restraint'. The problems posed by such high-demand patients have prompted the development of a variety of modifications in techniques of fixation,[5-7] in the materials used as a bearing surface,[8-11] in designs and in the introduction of bone-conserving procedures.[12-16]

Metal-on-metal total hip arthroplasty using cobalt-chrome alloy has been in use since the 1960s as a stemmed replacement.[17] Hip resurfacing using the same bearing began in 1991 in Birmingham by one of the authors (DJWM).[18] After the initial pilot series, from 1991 to 1993, to determine the best method of fixation, the hybrid form of this technique has been in use since March 1994.

This study analyses the early results obtained in a series of young active patients with osteoarthritis assessing the survival rate, the Oxford Hip Scores[19] and current levels of activity.

Patients and Methods

The components and the patients. From 1994 to 1996, the component used was the McMinn Resurfacing Hip Arthroplasty (Corin Medical Ltd., Cirencester, UK). This had an hydroxyapatite coated smooth metal uncemented cup and a cemented femoral component (Figs 1 and 2a). From 1997 to the present, the Birmingham Hip resurfacing (BHR) prosthesis (Midland Medical Technologies Ltd., Birmingham, UK) has been used. This has an hydroxyapatite on porous metal uncemented cup and a cemented femoral component (Figs 2b, 3a and 3b).

The 186 patients operated on in 1996 are excluded from the study as a unique pattern of failure occurred in the implants used with high metal wear, metallosis and osteolysis. This is believed to be due to problems in their manufacture.[20] Between March 1994 and April 2001, but excluding 1996, one surgeon (DJWM) carried out 446 resurfacing procedures on 384 patients aged less than 55 years with primary osteoarthritis of the hip. Of these, 43 hips were operated on in 1994 and

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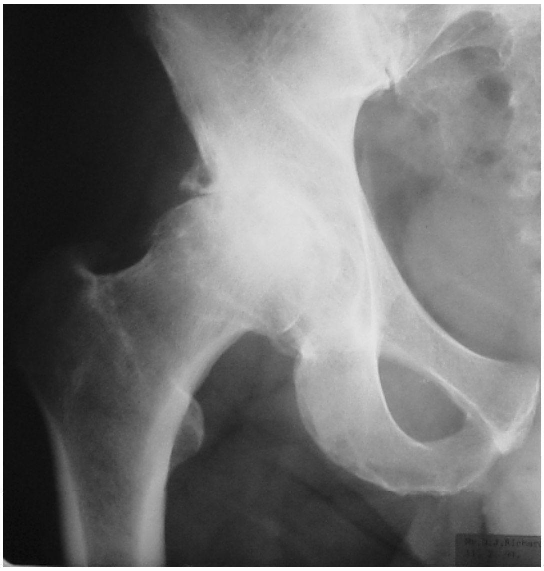

Fig. 1a

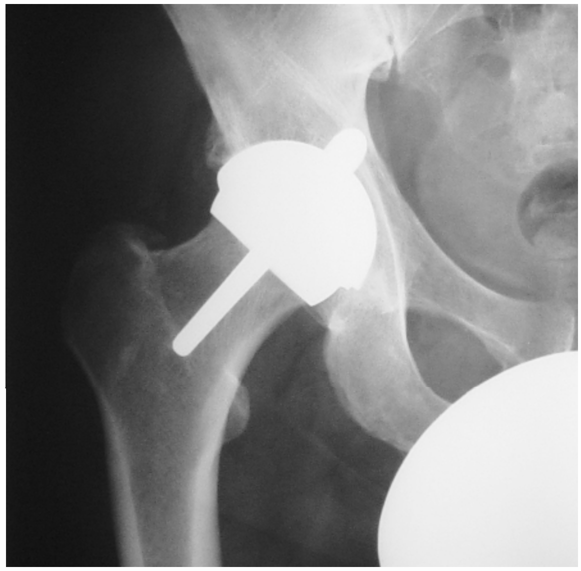

Fig. 1b

McMinn Resurfacing Hip Arthroplasty in a patient with osteoarthritis aged 53 years at operation. a) pre-operative x-ray and b) 7-year post-operative x-ray.

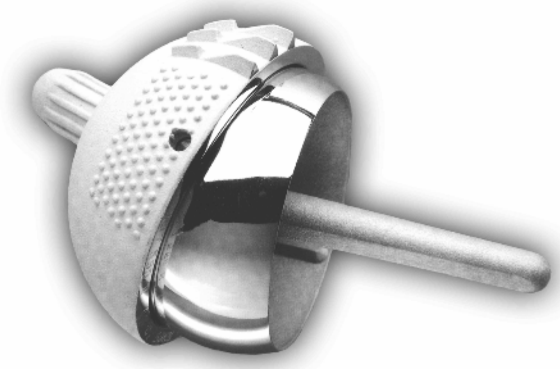

Fig. 2a

Fig. 2b

Components of McMinn Hybrid Hip Resurfacing (a) and Birmingham Hip Resurfacing (b).

1995 (McMinn Resurfacing devices) and 403 between July 1997 and April 2001 (BHRs).

Perioperative regimen. All operations were carried out in a clean air laminar flow environment with body exhausts. A posterior approach was used and the operative technique has been described elsewhere.[18,21] At induction of anaesthesia 1.5g of Cefuroxime was given with three further doses over the next 24 hours. From 1994 to 1996 patients were given warfarin during their inpatient stay, but from 1997 until March 1999 they received a single dose (800 IU) of intravenous heparin after insertion of the acetabular component.[22]

From March 1999 until the end of the study, intra-operative suction venting of the femoral shaft has been carried out to prevent systemic displacement of fat and marrow, which is known to activate the clotting cascade.[23] In addition, compression stockings and low-dose aspirin was continued for six weeks.

Fig. 3a

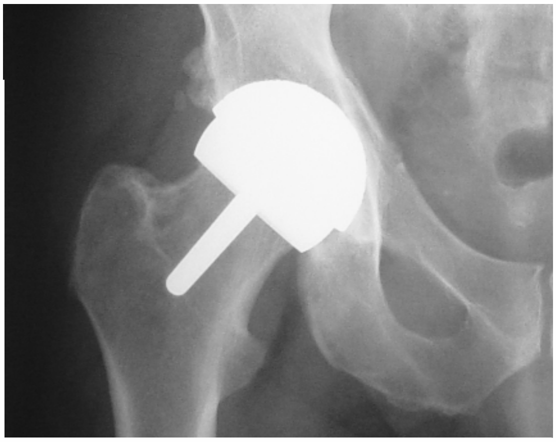

Fig. 3b

Birmingham Hip Resurfacing in a patient with osteoarthritis aged 45 years at operation. a) pre-operative x-ray and b) 5-year post-operative x-ray.

Table I. Life-table analysing the survival data of the 446 hips resurfaced

Years since operation	Number at start	Failure	Number at risk	Annual failure rate	Cumulative survival rate
0 to <1	446	1	445.5	0.22	99.78
1 to <2	444	0	391	0.00	99.78
2 to <3	338	0	279.5	0.00	99.78
3 to <4	221	0	174.5	0.00	99.78
4 to <5	128	0	84	0.00	99.78
5 to <6	40	0	40	0.00	99.78
6 to <7	40	0	36	0.00	99.78
7 to <8	32	0	20.5	0.00	99.78
8 to <9	9	0	4.5	0.00	99.78

Table II. Life-table analysing the survival data of the 403 Birmingham Hip Resurfacings

Years since operation	Number at start	Failure	Number at risk	Annual failure rate	Cumulative survival rate
0 to <1.5	403	1	378	0.26	99.74
1.5 to <2	353	0	326	0.00	99.74
2 to <2.5	299	0	269.5	0.00	99.74
2.5 to <3	240	0	209	0.00	99.74
3 to <3.5	178	0	154.5	0.00	99.74
3.5 to <4	131	0	108.5	0.00	99.74
4 to <4.5	86	0	54.5	0.00	99.74
4.5 to 5	23	0	11.5	0.00	99.74

Full weight bearing with a Zimmer frame was started on the first day after operation. Patients gradually made a transition from two elbow crutches to walking sticks and were discharged on the sixth post-operative day. After six weeks they were taught range of movement exercises for the hip and encouraged to gradually increase their activities. They were advised to swim or exercise in a pool and to undertake non-impact or low impact exercises in the gym. They were recommended to avoid high impact activities during the first year after the operation.

Methods of assessment. An analysis was performed using a life-table (Tables I and II) and a survival curve (Figs 4 and 5) to assess the cumulative survival of the implants. The Oxford Hip Score was used to assess pain, mobility and function. The activity levels of the patients were rated using a modified version of the University of California Los Angeles (UCLA) Activity Level Scale[24] (Table III). Data were collected and analysed using Excel and the R-statistical package.[25]

Results

Of the 384 patients included in the study, 302 were men and 82 were women. Their mean age at operation was 48.3 years (range 26.8 to 54.9). Their mean height, weight and body mass index (±SD) were 171.5 ± 8.5 cm, 81.8 ± 12.9 kg and 26 ± 3.4 respectively. Six patients (six hips), five men and one woman, died due to unrelated causes during the study period at between 0.7 to 4.7 years after their operations. The length of follow-up of the remaining patients ranged from 1.1 to 8.2 years (mean 3.3).

All 378 surviving patients (439 hips) were sent questionnaires in April 2002 and their responses were received in May/June 2002. Those 63 patients (16.7%) who did not respond to the questionnaires were contacted over the telephone and their responses were recorded. Thus, no patients were lost to follow-up.

There were no cases of nerve palsys, wound dehiscence, deep infection or dislocation. There was one thromboembolic event diagnosed clinically, a non-fatal pulmonary embolism in a patient operated on during 1995 who was on prophylactic warfarin.

The cumulative survival rate in the present study is summarised in Tables I and II. Figures 4 and 5 show a Kaplan-Meier survival curve for the resurfacing data. The results in the Swedish Hip Register for an equivalent patient group

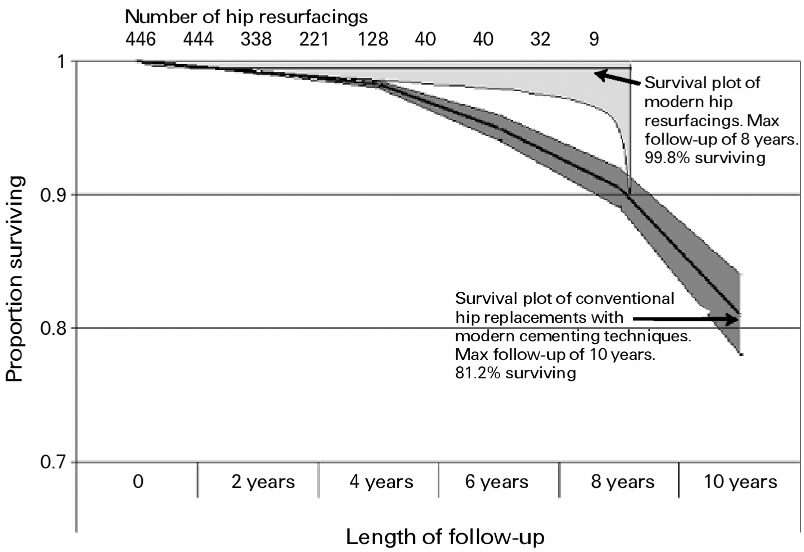

Fig. 4

Survival curve of hip resurfacings in patients (male and female) < 55 years with osteoarthritis compared with that of total hip replacements using modern cementing techniques (cohort 1988 to 1998) in male patients < 55 years with osteoarthritis from the Swedish Hip Register 2000 (all reasons for revision as the end point). Error bars indicate 95% confidence intervals.

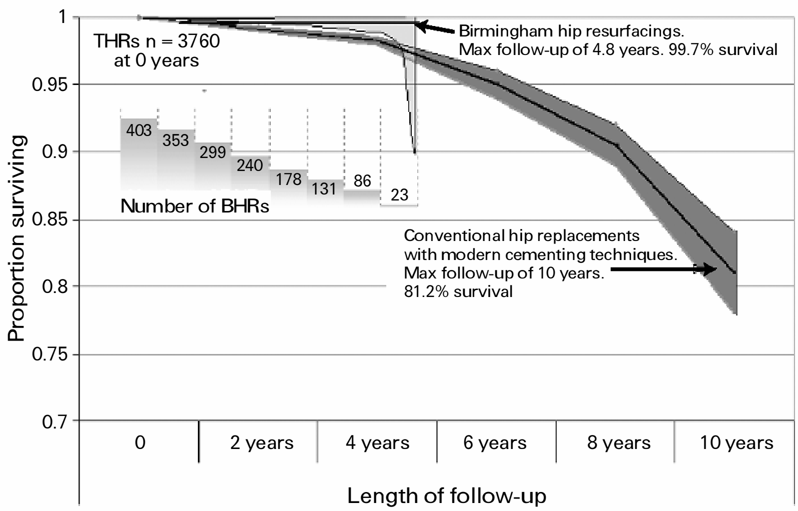

Fig. 5

Survival curve of Birmingham Hip Resurfacings only as a separate group (in patients < 55 years with osteoarthritis) compared with that of total hip replacements using modern cementing techniques (cohort 1988 to 1998) in male patients < 55 years with osteoarthritis from the Swedish Hip Register 2000 (all reasons for revision as the end point). Error bars indicate 95% confidence intervals.

are shown for comparison. The Swedish data have been measured from their publication.[1] The lower 95% confidence limits for the resurfacing data have been calculated according to Peto's method;[26] these may be conservative.[27] There is a significant difference between the survival curves up to the seven-year stage. The number of resurfacings at the eight-year stage is too small (n = 9) to be confident that there is a true difference. Only one hip, in a patient aged 54.4 years, had to be revised eight months after the operation. The cause of failure was avascular necrosis of the femoral head. The hip was revised to a ceramic-on-polyethylene total replacement.

If we consider the Birmingham Hip resurfacings separately (Table II), we find that there is very little change in the percentage surviving (99.7%). The difference in survival as compared to the Swedish results is still significant at the 4-year stage (Fig. 5). However, the number of patients (n = 23) in the interval between 4.5 and 5 years is not large enough to statistically establish a significant difference. The length of follow-up of these patients ranged from 1.1 to 4.8 years (mean: 2 years and 11 months).

The median Oxford score of the 439 surviving hips (378 patients) was 12 (75 and 95 percentiles of 13 and 18 respectively). Nineteen hips (17 patients) had a score above the 95th percentile. Of these, eight made the comment that their operated hip was fine and was not causing any symptoms and that their lower functional ability was due to pain from the other hip or another joint such as the knee.

The UCLA activity level ratings are given in Table III. The activity form was completed for 369 patients (97.6%). All who responded had a score of five or more indicating an active life-style (Table IV); 92% of the patients with unilat-

Table III. University College Los Angeles Activity Level Scale modified to include activities relevant to the patient population (*modifications in italics*)

Modified UCLA Activity Scale		
Level	**Activity**	**Examples**
1	Inactive	Wholly inactive. Dependent on others. Cannot leave residence.
2		Mostly inactive. Restricted to minimum activities of daily living.
3	Mild activity	Sometimes participates in mild activities such as walking, limited housework and shopping.
4		Regularly participates in mild activities. *Sedentary occupational work.*
5	Moderate activity	Sometimes in moderate activities such as swimming and can do unlimited housework or shopping.
6		Regularly participates in moderate activities. *Light occupational work.*
7	Active	Regularly participates in active events such as bicycling, *aqua-aerobics. Gardening or working out in the gym once or twice a week.*
8	Very active	Regularly participates in very active events such as bowling, golf. *Riding, hunting, aerobics. Gardening or working out in the gym three times per week or more. Moderately heavy occupational work. Farming.*
9	Impact sports	Sometimes participates in impact sports such as *running,* jogging, tennis, *cricket, baseball, rugby, football, hockey, racquet sports, judo, karate and other martial arts,* skiing, acrobatics, ballet dancing, backpacking and *mountaineering. Heavy occupational work.*
10		Regularly participates in impact sports as described above.

Table IV. Activity level ratings of the 378 patients using the modified UCLA Scale

Activity level	Male patients with unilateral hip resurfacings	Male patients with bilateral hip resurfacings	Female patients with unilateral hip resurfacings	Female patients with bilateral hip resurfacings	Total
10	117 (46.4%)	20 (44.4%	14 (21.9%)	4 (23.5%)	155 (41.0%)
9	40 (15.9%)	3 (6.7%)	7 (10.9%)	2 (11.8%)	52 (13.8%)
8	66 (26.2%)	14 (31.1%)	16 (25.0%)	4 (23.5%)	100 (26.5%)
7	10 (4.0%)	2 (4.4%)	9 (14.1%)	0 (0.0%)	21 (5.6%)
6	12 (4.8%)	1 (2.2%)	9 (14.1%)	4 (23.5%)	26 (6.9%)
5	4 (1.6%)	4 (8.9%)	4 (6.3%)	3 (17.6%)	15 (4.0%)
Unspecified	3 (1.2%)	1 (2.2%)	5 (7.8%)	0 (0.0%)	9 (2.4%)
Total patients	252	45	64	17	378

eral hip resurfacings and 87% of the whole group play sport; 62% of the men with unilateral hip resurfacings and 51% of men with bilateral procedures participate in impact sports. Amongst women, the figures are 33% (unilateral) and 35% (bilateral). Of the entire group, 58.7% participate in these activities more than twice a week and another 23.8% at least twice a week.

Discussion

Survival analysis in young active patients. Young and active patients with osteoarthritis of the hip present a considerable challenge,[28] particularly when male, in an active job and wishing to play sport or engage in physical activity.

In 1994, Dorr et al[2] showed that in patients under 45 years of age who had a cemented THR, a diagnosis of osteoarthritis or osteonecrosis gave the poorest results. Patients under the age of 30 years with osteoarthritis had no satisfactory results when reviewed after 16 years. Other authors[29,30] described similar unsatisfactory results although Cornell and Ranawat[31] found an 87.6% survival at ten years in patients under the age of 55. A high level of pelvic osteolysis[5,32,33] has been observed in these younger patients with increased wear of the socket and consequent loosening. More recently, different bearings and fixation systems have been used with improved results. The fact that osteotomies of the femur are still being presented as a viable treatment for advanced arthritis of the hip in young patients[14,15] suggests the inadequacy of conventional hip replacement for this group.

The 99.8% survival seen in the present study with a consecutive series of young patients with osteoarthritis suggests that metal-on-metal hip resurfacing is very effective for end-stage arthritis in this difficult group. The Swedish Hip Arthroplasty Register 2000[1] found that young women and men with osteoarthritis have the worst results. The Register gives the comparison in the same age group (under

55 years) with the same diagnosis (osteoarthritis). The survival rate in the Swedish study is 81.2% in men and 79.7% in women at the ten-year stage in those patients in whom modern cementing techniques were employed. In the older cohort, where earlier cementing techniques were used, the survival rate is 32.9% in men and 43.7% in women at the 16-year stage. The cumulative survival rate in the present study (99.8%) at a follow-up of 1 to 8 years is clearly superior to that in the Swedish Register.

It could be argued that two types of devices have been used during the period of this study, and that small changes in component design can lead to dramatic effects on the performance. The differences are in the manufacture of the two devices. The McMinn Resurfacing implant underwent a single heat treatment after casting whereas the BHR is in the as-cast state. The BHR has an integral porous surface with hydroxyapatite (HA) coating for acetabular fixation, as compared to the McMinn device which has an HA coated smooth surface.

However, there has been no failure related to the bearing or fixation in either group. These small changes have not affected the survival rate of the devices over the study period and both are doing well in the great majority of patients, although difference in performance may become evident over an extended period of follow-up.

In 1996, the components were subjected to two post-cast heat treatments. This resulted in microstructural changes in the metal, deterioration of wear characteristics and an increased early failure rate from metallosis and osteolysis.[20] These bearing-related failures seen from implantations during 1996 serve as a warning that untested changes to a design or manufacturing process may have detrimental effects on the performance.

In a recent review, McCulloch et al[34] point out that in evaluating surgical procedures, randomised controlled trials (RCTs) are not always practicable. The alternatives include building comprehensive prospective databases about operations and outcomes, using incremental quality improvement approaches to making changes and evaluating their effects. Others[35,36] have expressed similar views in the context of hip arthroplasty. They suggest that the proper method in such a situation is a phased-in clinical trial after pertinent bench testing, rather than an RCT.

In terms of bench testing, the device used in this study is based on the cumulative evidence of the historic metal-on-metal replacements and the lessons learned from experience with hip resurfacing by others in the 1980s. A better understanding of the ideal geometry for optimal tribological function has been gained from laboratory study.[37]

For evaluation of outcome, we have used the Oxford Hip Score which is of proven value. Unfortunately it is unable to distinguish between the symptoms from the operated hip and those from the contralateral hip or another joint. Out of 439 surviving hips, 21 patients specifically reported having reduced functional ability due to pain from an arthritic contralateral hip or another joint such as the knee. The Oxford scores of the remaining 418 hips ranged from 12 to 29. Of these, there were only two patients (three hips) with scores above 24. One patient with a score of 29 has returned to work as a physical education teacher and also regularly participates in swimming, cycling and badminton. His radiographs revealed no adverse changes. The other patient (two hips) had no pain but poor function due to motor neurone disease. None of these patients (with scores between 12 and 24) reported severe pain or limitation of function in the resurfaced hip.

Patients regard resumption of physical activities as one of their highest priorities.[38] Therefore, when considering the results of hip arthroplasty, it is very important to look at outcome in terms of return to physical activities. It has been well established that high levels of physical activity increase the rate of wear with the consequent possibility of early failure. Many surgeons ask their patients to refrain from high-contact, high-impact sports,[29,39-41] and acceptance of this advice does appear to enhance the rates of survival.

Following hip resurfacing, return to high-impact activities has to be carefully planned in a graded manner. Doing too much too soon risks a fracture of the neck of the femur. However, with time, periarticular osteopenia is reversed[42] and the protective effects of muscle tone, strength and co-ordination return to normal. Patients are then able to undertake more rigorous activities safely.

The UCLA Activity Level Scale,[24] modified to include activities relevant to the UK, was used to rate the level of activity. We have found that patients can safely return to levels of activity, which would have been neither advisable nor possible with conventional hip replacement (Table IV). No patient was asked to refrain from any physical activity in the long term and most were able to return to their pre-arthritic level by a year after operation. None changed their occupation following surgery including those who were involved in heavy activities at work, such as on building-sites. One third of the men were involved in jobs that involved heavy or moderately heavy work. Only 4% of patients were retired, unemployed or did not specify their occupation. For many such as sports professionals, physical education teachers, farmers and personnel from the police and fire services, return to high demand activities is essential to their careers.

Many patients indicated that they had forgotten about their hips and were able to function as normal. This is probably related to two factors. First, the presence of a normal sized head of femur in its normal location makes dislocation a rare event. This allows the patient to regain a full range of movement of the hip without the fear of dislocation. Second, the pattern of loading of the proximal femur after a resurfacing procedure is more physiological than after a stemmed replacement, giving compressive forces rather than hoop stresses. This normal loading is believed to reverse the proximal femoral osteopenia which is commonly found in an arthritic hip. Using DEXA (dual-energy X-ray absorptiometry) studies, Kishida et al[42] have shown that the bone mineral density in the proximal femur improved by 12% in Gruen zone 7 two years after hip resurfacing, enabling patients to resume higher levels of activity. This effect is the opposite of that seen in a conventional hip replacement[43-45] in which the loss of bone density around the proximal part of the stem is estimated at between 16% and 29% following a stemmed hip replacement. Engh et al[46] studied post mortem femora with DEXA scanning and found a 7% to 52% loss of bone mineral density in the proximal femur as a result of periprosthetic remodelling around well functioning cementless total hip replacements fixed by osseointegration. With conventional hip replacements, the accepted reality is that the more active a person is, the higher the rate of polyethylene-wear and the greater the rate of failure.[47] No such adverse effect of activity has been seen over the follow-up period with metal-on-metal hip resurfacing.

This study, with a maximum follow-up of eight years, is too short to come to any definite conclusions. High demand patients with end stage osteoarthritis have been a clinical problem that has defied the search for a solution. For the particular challenge of young patients with arthritis of the hip where existing procedures have consistently failed to produce a satisfactory answer, metal on metal resurfacing manifests evidence of significant superiority over existing treatments. Most devices are known to show two phases of high failure, one early and another in the later years.[48] The early failure with this modern metal-on-metal resurfacing has been very low in the hands of an experienced surgeon. The interim years are continuing to be problem-free and we are yet to find out when the late failures, if any, are likely to occcur. Caution still needs to be exercised until longer term results are available.

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