We review the history and literature of hip resurfacing arthroplasty. Resurfacing and the science behind it continues to evolve. Recent results, particularly from the national arthroplasty registers, have spread disquiet among both surgeons and patients. A hip resurfacing arthroplasty is not a total hip replacement, but should perhaps be seen as a means of delaying it. The time when hip resurfacing is offered to a patient may be different from that for a total hip replacement. The same logic can apply to the timing of revision surgery. Consequently, the comparison of resurfacing with total hip replacement may be a false one. Nevertheless, the need for innovative solutions for young arthroplasty patients is clear. Total hip replacement can be usefully delayed in many of these patients by the use of hip resurfacing arthroplasty.

Few operations have attracted as much attention, and in some cases emotion, as hip resurfacing arthroplasty, particularly in recent years. It therefore seems reasonable to evaluate the current status of the procedure, especially as some reports suggest that all is not well with hip resurfacing. This was highlighted in the recent alert for all metal-on-metal hip replacements issued by the Medicines and Healthcare Products Regulatory Agency in the United Kingdom.\(^1\)

Previous attempts at resurfacing will be discussed and the reasons for their failure highlighted. The development and literature on the current generation of resurfacing implants will be reviewed, in order to consider whether there is still a place for hip resurfacing arthroplasty in modern hip surgery.

**History**

Hip resurfacing began in the early 1900s as interposition arthroplasty,\(^2\) most commonly using fascia lata, although in 1912, Sir Robert Jones is reported to have used gold foil.\(^2\) Smith-Petersen’s results\(^3\) with glass in the early 1920s were initially so successful that, although the components broke within a few months, he continued to search for a more durable alternative. In 1940 this resulted in his cast cobalt-chrome-molybdenum alloy (vitalium) interposition cup.\(^3,4\)

Charnley, before his success with low-friction arthroplasty, experimented with a polytetrafluoroethylene hip resurfacing as a continuation of Smith-Petersen’s work.\(^4\) He reported that these resurfacings worked well for the first two to three years and then failed rapidly. He initially blamed this on avascular necrosis of the femoral head, but subsequently identified the wear debris from polytetrafluoroethylene as another potential cause.\(^4,6\)

In the 1970s interest was renewed, with polyethylene acetabular components articulating with metal femoral heads. Initial results were promising and several designs entered the market. The Wagner metal-on-polyethylene prosthesis, in a series of 100 consecutive cases achieved 70% survival at five years, but by eight years this had dropped to 40%.\(^7\) These poor results were repeated with other designs, and the initial enthusiasm for hip resurfacing was rapidly lost. The large surface area of these hard-on-soft bearings produced significant volumes of polyethylene wear debris, inciting macrophages and triggering osteolysis. Revision of these implants, however, was not difficult and the results at that time were believed to be better than for revisions of total hip replacement (THR).\(^8,9\)

The prolonged survival of certain Ring and McKee-Farrar metal-on-metal THRs provided the next stimulus.\(^10,11\) This option had lost favour because of higher early revision rates than with metal-on-polyethylene THR. Analysis of the long-term metal-on-metal survivors, many still functioning after more than 20 years, identified certain survival traits. These included polar rather than equatorial bearing, and more open and anteverted acetabular components than had been initially recommended.\(^12,13\)
McMinn et al.\textsuperscript{14} identified several factors which they felt critical to the success of any future resurfacing prostheses. These included minimising wear debris, thin components to maximise the preservation of bone, a large-diameter femoral component and sound surgical technique, in particular to avoid femoral notching and varus placement of the femoral component.\textsuperscript{14} These factors were based largely on analysis of hip resurfacing failures and metal-on-metal successes.\textsuperscript{11,13} They felt that osteolysis could be overcome with a hard-on-hard bearing using high-carbon cobalt-chrome implants.

The first McMinn prosthesis was implanted in February 1991.\textsuperscript{14} The group’s early to mid-term results of 446 hip resurfacings, including the McMinn prosthesis and its subsequent modifications, reported few complications, with only one revision and no femoral neck fractures at a mean follow-up of 3.3 years (maximum 8.2).\textsuperscript{15} There has been much controversy regarding the decision to exclude the 186 prostheses implanted in 1996 from this and other papers.\textsuperscript{16} However, the ten-year results for the 1996 cohort have recently been published,\textsuperscript{17} and it seems clear that the double-heat treatment applied to these implants significantly impaired their wear characteristics and survival.\textsuperscript{18,19} Meanwhile, Amstutz and Le Duff,\textsuperscript{20} in a recent update on the Conserve plus prosthesis (Wright Medical Technology, Arlington, Tennessee), reported on 1000 resurfacings at a mean of 5.6 years (1.1 to 11.0) after implantation. There were 34 revisions of which ten were for femoral neck fractures, and there were no exclusions from the series.

In general, therefore, good early and mid-term results were produced for this current generation of resurfacings by their developers,\textsuperscript{14,15,20,21} and this was followed by the widespread re-adoption of hip resurfacing by the more general orthopaedic community.

The present

Much of the demand at the beginning of this century for hip resurfacing was patient driven, with explicit internet marketing which still continues.\textsuperscript{22} In April 2006 The Times business section reported that resurfacing “.... is far less traumatic than replacement therapy and the company (Smith & Nephew) confidently predicts that it will account for more than 50 per cent of all hip surgery by 2009”\textsuperscript{23} It became common for younger, and indeed not so young, patients to attend clinics requesting this procedure. Many of the manufacturers not represented in this initial wave of enthusiasm soon developed and advertised their own designs, keen not to lose a share of what was seen as a lucrative new market. The longer term evidence in support of many of these newer prostheses has not been strong.\textsuperscript{24,25}

As hip resurfacing has become more popular more complications have appeared in the literature.\textsuperscript{26,27} These include femoral neck fracture, wear debris, malposition, avascular necrosis, dislocation and pseudotumours. Initial interest focused on femoral neck fractures, which had been remarkably rare in McMinn’s series.\textsuperscript{15} Although debated, this may be related to bone mineral density and surgical technique,\textsuperscript{28,29} and careful patient selection has reduced this complication.\textsuperscript{20,30}

Metal-on-metal arthroplasties produce lower volumes of wear debris than conventional metal-on-polyethylene bearings.\textsuperscript{31,32} However, the individual particles from the former are much smaller, and therefore the load in terms of the number of particles and their total surface areas is significantly higher.\textsuperscript{32} Polycarbonate wear debris is largely contained around its prosthesis whereas the nanometer-sized metal-on-metal wear debris has been shown to be widely distributed throughout the body.\textsuperscript{33} Metal ions continue to be released by the steady depapsulation and repassivation processes over the large surface area of these particles.\textsuperscript{34}

The initial concerns of an increased risk of cancer\textsuperscript{35-37} have not been supported by retrospective reviews of the original Ring and McKee-Farr THRs.\textsuperscript{38} However, it is still recommended that these prostheses be avoided in women of childbearing age and those with renal impairment.\textsuperscript{16,39}

The importance of the position of the acetabular component to both the level of metal ions and the survival of the implant has been widely reported, both in vitro\textsuperscript{40} and in vivo.\textsuperscript{27} An abduction angle of more than 55° and anteverision of more than 30° should be avoided because of edge loading, accelerated wear and early failure.\textsuperscript{18,44} Technically, however, the optimal positioning of uncemented acetabular components in young, muscular patients or the obese can be difficult, with the role of adequate surgical assistance ignored in the literature. The role of computer navigation also remains unresolved.\textsuperscript{45-47}

The preservation of femoral bone stock with hip resurfacing also brought concerns about preserving the blood supply to the femoral head.\textsuperscript{48-50} The importance of the medial femoral circumflex artery was already well known,\textsuperscript{48} and this was emphasised by clinical studies that assessed blood flow and surgical approach.\textsuperscript{49,50} However, these findings have not translated into significant problems with failure of implants due to avascular necrosis.

Because of their larger components, dislocation rates in hip resurfacing have been much lower despite patients' widely reported increased levels of activity.\textsuperscript{15,20,51,52} This benefit has played a significant role in promoting large-headed components for younger patients undergoing resurfacing or THR. However, there is disagreement in the literature about the benefits in relation to functional and quality of life outcomes between hip resurfacing and THR in younger patients.\textsuperscript{53-55}

Pseudotumours are a worrying complication of hip resurfacing and are the basis for the recent Medicine and Healthcare Products Regulatory Agency device alert.\textsuperscript{1,56,57} Their formation has been related to excessive metal ion production and hypersensitivity. Histologically, there are acute lymphocytic vascular associated lesions, although the basic science behind these lesions is still not fully understood.
The incidence varies widely between studies, but women under 40 years of age appear to be at greatest risk.56,57 The outcome of revision for pseudotumour has been shown to be poor in terms of both functional recovery and the need for further revision surgery.57

The increased complication rate for resurfacing as reported by surgeons from the non-originating centres is not surprising, and supports the argument that there is a significant learning curve for the procedure.18,52 Improved patient selection is an easily recognised part of this.58,59 The surgery is technically more difficult and the tolerances of these implants appear smaller than for traditional THRs.60 These factors make the role of resurfacing by low-volume surgeons more uncertain.

The registers
Hip resurfacing arthroplasty appears on a number of arthroplasty registers, although so far none has significant ten-year data.

Sweden has been cautious in adopting resurfacing. A 2008 report61 included 1041 resurfacings which had been registered since 1996, with a mean follow-up of 2.2 years (sd 1.7). There were 35 revisions, of which 11 were for fracture. The authors recommended that hip resurfacing should be limited in its use and the patients reviewed regularly.61

For England and Wales a 2009 report24 found the overall three-year revision rate for hip resurfacing arthroplasty to be 4.5% (95% confidence interval (CI), 4.0 to 4.9; n = 11 770), compared to 1.3% (95% CI 1.2 to 1.4) for a traditional THR. The lowest revision rates at three years were for hip resurfacings in men aged 55 to 64 (3.1%; 95% CI 2.4 to 3.9; n = 2886) and the highest in women over 65 (8.5%; 95% CI 5.3 to 13.6; n = 265). A strong association (p < 0.0001) was found between the design and the revision rate. The BHR (Birmingham Hip Resurfacing; Smith & Nephew, Memphis, Tennessee) performed best (3.3%; 95% CI 2.9 to 3.9, n = 6746), and the ASR (Articular Surface Replacement; DePuy, Warsaw, Indiana) the worst (7.5%; 95% CI 5.9 to 9.5, n = 1332).24 The ASR hip resurfacing and THR has now been recalled by the manufacturer.62

A 2008 Australian report,25 covering just over eight years of hip arthroplasty activity, included 12 093 resurfacings, representing 7.6% of all primary hip arthroplasties in this period. The use of resurfacing, as recorded by the Australian National Joint Replacement Register, fell from a peak of 1832 in 2005 to 1442 in 2008, of which 79.6% (n = 11 448) were in men and 54.6% (n = 788) were in patients under 55. The three- and eight-year revision rates were 3.2% (2.9% to 3.6%) and 6.1% (5.3% to 6.9%), respectively. On further analysis, femoral components 44 mm or less in diameter had a fourfold increased risk of revision at seven years compared with femoral components with a diameter of 55 mm or more. Again, the BHR performed best, with an eight-year revision rate of 5.0% (4.3% to 5.8%), with the five-year revision rate for the ASR at 8.7% (6.6% to 11.5%) and 6.7% (4.7% to 9.7%) for the Durom.25 Although longer term results are needed, many of the patterns identified in the general literature26,27 are supported in the registry data.

The age at which hip arthroplasty is offered is falling,44 and this is particularly true for hip resurfacing.25 This may be related to the perception that when a resurfacing fails, a THR can be performed without great difficulty. Equally, it may also be that the threshold for revising a hip resurfacing to a THR is lower than the threshold for revising a THR. This makes it difficult to compare the failure rates of hip resurfacing and THR accurately.

The future
Evidence is required to substantiate advances in arthroplasty surgery, but whether it is reasonable to compare a hip resurfacing arthroplasty with a THR is debatable. Resurfacing may perhaps be best seen as a preliminary step to a THR. The short-term results of converting hip resurfacing to THR in the absence of acute lymphocytic vascular associated lesions are equivalent to those of primary THR.63,64 Whether the totality of arthroplasty survival over a single patient's lifetime is improved by the use of resurfacing as the primary procedure is unanswered.

The need for innovation was highlighted in 2005 by a report that the 13-year survival rate for THRs in men under 50 years of age was 73.5% (95% CI 68.5 to 78.5, n = 3122).65 Modest improvement has been seen with the most recent generation of total hip prostheses66 but the problem of the young prospective hip arthroplasty patient remains unsolved.

The argument over acetabular bone preservation between resurfacing arthroplasty and THR is probably irrelevant. The differences are small, with studies supporting both sides of the argument, depending on which components are used.67-69 What is more important is the probability that young hip arthroplasty patients will in due course need several revisions. The planning and provision of surgery for these patients requires consideration of at least the next 30 years of their lives. With careful patient selection, hip resurfacing has a role, particularly in young men with osteoarthritis. Results for women are less convincing, but there may be such a role in selected cases.

Hip resurfacing is a distinct procedure from THR. The threshold for its use in current practice appears to be different to that for THR. The operative technique and complications, albeit sharing some similarities with THR, also have considerable differences. Thus, resurfacing arthroplasty is maturing into its own position in the orthopaedic armamentarium. Initial enthusiasm has been replaced by a more balanced view of its merits and disadvantages. As with THR, certain designs are achieving better results, and surgeons must remain responsive to this. The orthopaedic principle of delaying THR for as long as possible remains, with hip resurfacing a useful option to help achieve this.70,71
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