Focus On

Hip resurfacing arthroplasty

Introduction
This review will consider the historical context of resurfacing, the tribology, the published clinical results and current controversies and concerns.

Historical context
The concept of resurfacing the hip can be traced back to the early 1900s with the various techniques of interposition arthroplasty. Smith-Petersen produced a cast cobalt-molybdenum alloy (vitallium) interposition cup in 1940 as a culmination of many years work with different materials. Charnley experimented with a polytetrafluoroethylene (PTFE) hip resurfacing as a clear continuation of Smith-Petersen’s earlier work before developing his low friction arthroplasty. He found his resurfacings worked well for two to three years and then rapidly failed. He initially attributed these failures to avascular necrosis of the femoral head but his subsequent observations, including experiments on himself, led him to blame PTFE wear debris. In the 1970s interest was renewed, with polyethylene acetabular components mated with metal femoral heads. Initial results were promising but by eight years 40% survival was typical, resulting in this technology being largely abandoned. The large surface area of these hard-on-soft bearings produced significant volumes of polyethylene wear debris, inciting macrophages and triggering massive osteolysis. In the mid-1980s it became apparent that some Ring and McKee-Farrar metal-on-metal total hip replacements (THRs) were continuing to function well over 20 years after the primary operation. From these observations a new generation of hard-on-hard bearing hip resurfacings was born, manufactured from high-carbon cobalt-chrome.

Biomechanical considerations
Tribology is the science and technology of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication and wear. The word ‘tribology’ derives from the Greek root “tribo” (rub), and the suffix “logos” (account, explanation, narrative).

The main theoretical advantage of large-head metal-on-metal prostheses is that they allow for periods of fluid film or elastohydrodynamic lubrication which greatly reduces wear. Generating the fluid film requires that the joint surfaces are moving across each other at sufficient speed with adequate fluid entrapped within the joint. When this is not achieved boundary lubrication and much higher wear occurs. Thus, overall the large head prostheses are described as showing a mixed lubrication regime.

The poor results seen with malorientated acetabular components likely relate to concentrated or edge loading with loss of fluid film lubrication. The resultant high wear is associated with early failure. This is more common for those designs where the sector angle of the acetabular component is reduced. Similarly the poor results with smaller component sizes are likely to be related to a failure of fluid film generation and hence increased wear.

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Clinical results
The first McMinn prosthesis was implanted in February 1991. 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 years). There has been much controversy regarding the decision to exclude the 184 prostheses implanted in 1996 from this and other papers. However, the ten year follow-up data for the 1996 cohort have recently been published. It is quite possible that the double heat treatment which was applied to these implants significantly impaired their wear characteristics and survival. As hip resurfacing moved out of the hands of the designer surgeons into the general orthopaedic community so more complications appeared in the literature.
focused on femoral neck fractures, which had been remarkably rare in McMinn's series.26 Although debated, this seems largely related to pre-existing bone mineral density and surgical technique.29,30 Careful patient selection has significantly reduced this complication.31,32

The nanometer-sized metal-on-metal wear debris has been shown to be widely distributed throughout the body.33 Metal ions continue to be released by the steady depassivation and repassivation processes over the large surface area of these particles.34 The initial concerns with an increased cancer risk35,37 have not been supported by retrospective reviews of the original Ring and McKee-Farr THR.38 However, it is still recommended that these prostheses be avoided in women of child-bearing age and those with renal impairment.39,40

The 2008 National Joint Registry report (England and Wales)41 found the overall three-year revision rate for hip resurfacing arthroplasty to be 4.5% (95% confidence interval (CI) 4 to 5; n = 11770) as compared with 1.3% (95% CI 1.2 to 1.4; n = 86524) for a traditional total hip replacement (THR) with a cemented femoral component. The lowest revision rates at three years were for hip resurfacings in men aged 55 to 64 years (3.1%; 2.4 to 3.9; n = 2886) and the highest in women over 65 years (8.5%; 5.3 to 13.6; n = 265). A strong association (p < 0.0001) was found between the design used and revision rate. The BHR (Birmingham Hip Resurfacing; Smith & Nephew, Memphis, Tennessee) performed best, (3.3%; 2.9 to 3.9, n = 6746), and the ASR (Articular Surface Replacement; DePuy, Warsaw, Indiana) the worst, (7.5%; 5.9 to 9.5, n = 1332).42 The ASR is no longer being actively marketed and will be shortly withdrawn (personal communication DePuy, UK). The ASR femoral component is heat treated and the acetabular component has a reduced sector angle.

The 2008 report for the Australian National Joint Replacement Register5 details just over eight years of hip arthroplasty activity, included 12093 resurfacings, representing 7.6% of all primary hip arthroplasties reported in this period. The reported use of resurfacing to the register fell from a peak of 1832 in 2005 to 1442 in 2008 of which 79.6% (n = 1148) were in men and 54.6% (n = 788) were in patients under 55 years of age. The three- and eight-year revision rates were 2.7% (2.4 to 3.1) and 6.7% (5.3 to 6.9), respectively. Further analysis found that femoral components of 44 mm or less in diameter had a fourfold risk of revision at seven years than femoral components which had a diameter of 55 mm or more. Again, on this registry, the BHR performed best with an eight-year revision rate of 5.0%. Meanwhile, the five-year revision rate for the ASR was 8.7% but 6.7% for the Durom (Zimmer, Warsaw, Indiana),40 The key advantage of registry data is the significant reduction in reporting bias.

Concerns & controversies
Pseudotumours are a worrying complication of hip resurfacing.19,43 They have been related to excessive metal ion production and metal ion hypersensitivity. Histologically, an acute lymphocytic vasculitis is often seen, resulting in the formation of acute lymphocytic vascular associated lesions (ALVAL), although the basic science behind these lesions is still not fully understood. The incidence varies widely between different studies but women under forty years of age appear to be at greatest risk.19,42 Furthermore the outcome of revision for pseudotumour has been shown to be poor in terms of both the functional recovery and the need for further revision surgery.43

The initial enthusiasm surrounding resurfacing has not been maintained. However, the urgent need for innovation was highlighted by a report in 2005 which reported a 13-year survival rate for total hip replacements in men under 50 years of age of 73.5% (95% CI 68.5 to 78.5).43 Modest improvement has been seen with the most recent generation of total hip prostheses44 but the young prospective hip arthroplasty patient still remains a conundrum. The short-term results of converting hip resurfacings to THRs in the absence of ALVAL are equivalent to those of primary THR.45,46 Whether the totality of arthroplasty survival over a single patient's lifetime is improved by the use of a resurfacing as the primary procedure remains unanswered.

References