■ ORTHOPAEDIC CROSSFIRE®: CONTEMPORARY TECHNOLOGIES

Metal-on-metal hip arthroplasty

GOING, GOING, GONE... – OPPOSES

H. Benjamin-Laing,
F. S. Haddad

*From University
College London
Hospitals, London,
United Kingdom*

In this paper, we will consider the current role of metal-on-metal bearings by looking at three subtypes of MoM hip arthroplasty separately: Hip resurfacing, large head (> 36 mm) MoM THA and MoM THA with traditional femoral head sizes.

A solution for the young arthritic patient with high function and high demands is still lacking. The ideal prosthesis should be made of a material that is durable, permits low friction movement at the articulating surface and is inert. Conventional total hip arthroplasty (THA) using a metal femoral component and polyethylene acetabular component has been found to have a 50% failure rate at 25 years in young active patients.¹ These high failure rates with polyethylene were prior to the use of highly cross-linked polyethylene over the past ten years.

Polyethylene wear is a major concern as younger patients often attempt to maintain/regain their pre-operative level of activity. This has resulted in renewed interest over the last two decades in metal-on-metal (MoM) bearing surfaces. The use of a MoM bearing surface produces less wear and is self-polishing,² which allows for self-healing of surface scratches.³

The initial success of modern hip resurfacing⁴ in both designer and non-designer centres⁵ must however be considered in the light of recent concerns regarding specific implants and bearing couples.⁶⁻⁹ In this paper, we will consider the current role of MoM bearings by looking at three subtypes of MoM hip arthroplasty separately: Hip resurfacing, large head (> 36 mm) MoM THA and MoM THA with traditional femoral head sizes.

Hip resurfacing

MoM hip resurfacing has long been recognised as an attractive concept particularly in young patients who are likely to need revision hip arthroplasty in their lifetime. Due to improvements in materials, design, and manufacturing techniques, MoM hip resurfacing arthroplasty gained popularity in the last decade with perceived advantages of bone conservation

and relative ease of revision to a conventional total hip arthroplasty if it fails.¹⁰

Hip resurfacing preserves proximal femoral bone stock, retains proprioception, optimises stress transfer to the proximal femur and, because of the large diameter of articulation, offers inherent stability and optimal range of movement.¹¹ This leads to a lower risk of dislocation and increased stability.¹² Intra-operatively the absence of femoral canal reaming in hip resurfacing theoretically reduces the risks of embolic phenomena.

Although modern hip resurfacing has recognised early complications, such as femoral neck fractures and avascular necrosis of the head, the early and medium term results were encouraging.⁵⁻⁷ The technique attracted a great deal of media attention and was rapidly taken up.¹³

MoM hip resurfacing was initially used as an option in very active people with advanced hip disease that would otherwise receive and are likely to outlive a conventional primary THA.¹⁴ Early success led to a widening of the indications and to the use of resurfacing cups with standard femoral stems and metal heads.

However, over the past few years concerns have been raised in relation to reports of catastrophic soft-tissue reactions resulting in implant failure and associated complications. Information from the Australian national joint registry demonstrates a higher revision rate for resurfacing when compared to THA (5.3% vs 4%).¹⁵ Interestingly, the same registry identifies that when adjusted for age and gender, better results were achieved in men below 55 years of age with osteoarthritis when comparing resurfacing to THA.

Overall the use of MoM hip resurfacing has declined from a peak of 6484 procedures in 2006 to 2512 in 2010/2011.¹⁶ Revision rates of 11.8% at seven years for resurfacing

■ H. Benjamin-Laing,
BSc(Hons), MBChB(Hons),
MRCS(Ed), Orthopaedic Surgeon
■ F. S. Haddad, MCh(Orth),
FRCS(Orth), Professor of
Orthopaedic Surgery
University College London
Hospitals, Department of
Trauma & Orthopaedic
Surgery, 235 Euston Road,
London NW1 2BU, UK.

Correspondence should be sent
to F. S. Haddad; e-mail:
fsh@fareshaddad.net

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implants paint a bleak picture but when results are individualised to specific implants the findings are different.

There is a large disparity in the revision rates of different resurfacing implants. The Birmingham Hip Resurfacing (BHR) (Smith & Nephew, Warwick, United Kingdom) had the lowest revision rate (3.4% at five years) in comparison to an overall revision rate of 4.9% for resurfacing prostheses. A higher revision rate of 9.63% in the ASR™ (DePuy, Warsaw, Indiana) due to excess metal debris and component loosening led to its withdrawal.^{15,17-19} The findings are similar in studies analysing Australian National joint registry data with revision rates at five years of 10.9% for the ASR compared to 4.0% for the rest of the resurfacing implants.²⁰ In 2010/11 there were 13 different brands of resurfacing implants being used of which only one met the Orthopaedic Data Evaluation Panel (ODEP) standards. In order to meet these requirements products need to comply with the ten-year benchmarks set out by the National Institute of Clinical Excellence (NICE).²¹ The BHR currently accounts for 51% of resurfacings in England & Wales and is the only resurfacing implant that has an ODEP 10A rating.

Female gender has been found to be associated with a higher incidence of pseudotumours however this may be due to the smaller head sizes used in females.²² Glyn-Jones et al²² found a revision rate at six years of 6% in those over 40 years and 13% in females below 40 years of age. The NJR found a revision rate of 10% in females under the age of 60 years at five years. This is in contrast to the revision rates in males below 60 years of 6.05% and is at least three times the revision rate of cemented, uncemented or hybrid THA.¹⁶ Small component size is a better predictor of failure than female gender.²³

Studies have demonstrated similar survivorship to THA in resurfacing head sizes above 50 mm in patients below 55 years of age.^{24,25}

Resurfacing failures seem to relate to poor technique including component malposition, use in unsuitable patients whose anatomy dictated malposition/edge bearing, and the wide introduction of some unsatisfactory implants with insufficient in vivo evaluation. The evidence from the literature is clear that all medical devices depend on appropriate surgical technique and patient selection. It appears that these simple rules affect the success of MoM hips more than other hip types.

De Haan et al²⁶ reviewed 214 patients who had hip resurfacing and found that steeply inclined acetabular components with inclination angles of > 55° combined with smaller size of component were likely to give rise to higher serum levels of Cobalt and Chromium. Malpositioning of the components can lead to earlier failure and revision.

We undertook a prospective randomised study of cementless THA with a 32 mm metal-on-polyethylene bearing versus MoM hip resurfacing in young adults under the age of 55 years. Eighty patients were enrolled between 1999 and 2002. All the patients have been followed clinically and radiographically up to a minimum follow-up

of eight years and a mean of 10.1 years. In this cohort, there have been no failures in the Metal-on-metal (MoM) articulation group and there has only been one dislocation in the total hip group. We have not encountered any pseudotumours or adverse tissue reactions documented in the literature. At this stage, on a deliberate cross-sectional imaging review unrelated to symptoms, we have four cases of resurfacing that have small effusions but these are asymptomatic and we do not believe that they warrant intervention. These patients do clearly warrant follow-up.

A higher proportion of hip resurfacing patients were running and involved in sport and heavy manual work after five years, eight years and ten years. The University College Hospital functional hip score showed significantly higher function in hip resurfacing patients compared with hip arthroplasty patients; this was maintained at one year, five years and eight to ten years. These results correlate with the early findings from Bow et al²⁷ that demonstrate improved function scores in young patients undergoing hip resurfacing. We continue to use hip resurfacing in such patients.

Hip resurfacing remains a viable successful operation in younger males with appropriate anatomy. Inclination angles above 55°, the use of resurfacing in females and those with small femoral head sizes is associated with higher failure rates. Additional risks exist in resurfacing due to the retained head and neck. Thus, clinical results currently best support the use of a resurfacing implant with a high ODEP rating, positioned with a cup inclination angle of 45° or less and version angle of 20° or less, to treat a man aged less than 65 years, suffering from osteoarthritis with a well-covered acetabulum and cam-shaped hips.^{28,29} In this cohort, there may well still be advantages to resurfacing.

Stemmed / modular large head (> 36 mm) MoM hips

The use of large MOM femoral heads on stems with resurfacing cups was a rapid evolution from modern resurfacing. It did not have the fracture and avascular necrosis risks of hip resurfacing and was technically much easier to perform. Reduced rates of dislocation, wear,³⁰ greater range of movement³¹ and potential for increased longevity made this an attractive option.

It transpires however that stemmed / modular large head (> 36 mm) MoM hips are at risk of problems possibly concerning the taper junction / trunnion. In a randomised controlled trial comparing the use of large head MoM THA to MoM resurfacing, the early follow-up results describe a higher concentration of blood Cobalt and Chromium ions in the THA group in comparison to the resurfacing group.³² Langton et al³³ showed a doubling of failure rate comparing the ASR™ (DePuy) to the total hip arthroplasty version the ASR XL (DePuy), due to "metal disease". Moreover they have seen failure with high metal ions without significant wear and others have noted that the failures of MOM THA are greater with larger head sizes (the opposite to hip resurfacing) supporting a different failure mode.

Evidence from the national joint registry of England and Wales report high failure rates in large head MoM THA compared with other types of bearing surfaces.³⁴ This is evidenced by failure rates of 5.1% for 52 mm head at 5 years in men aged 60 and revision rates in younger women at 6.1% for 46 mm metal-on-metal compared with 1.6% for 28 mm metal-on-polyethylene. This is in contrast to the findings of large head sizes in hip resurfacing which have better survivorship compared with smaller head sizes. Therefore as head sizes increase in metal-on-metal total hip arthroplasty revision rates increase.

For the time being, MoM hip arthroplasty on a stem with 36 mm heads or above should not be considered outside ethically approved research studies.

Second generation MoM bearing surfaces with 28 mm head sizes

Second generation MoM bearing surfaces with 28 mm head sizes have been in use for two decades. Eswaramoorthy et al³⁵ evaluated the ten-year clinical and radiological results of the Metasul MoM articulation (28 mm head). They concluded an acceptable implant failure rate within recommended targets established by NICE at ten-year follow-up. This study did, however, identify an ALVAL type lesion in two of the 6 implants that required revision. Other mid and long term studies looking at similar small head MoM THAs have reported implant survival of 95.5% and 94.4% at 12.3 years, with good clinical outcome scores and no evidence of metal reactions.^{36,37} Similar results were found in comparison with alumina ceramic on conventional polyethylene bearing at ten-year follow up.³⁸

The data on MoM hip arthroplasty with 28 mm heads supports continued use, but further detailed study will be required in order to evaluate whether there will be late metal on metal reactions and to understand the underlying risk factors. At present, there is no added advantage of the MoM arthroplasty with 28 mm heads over the gold standard of metal-on-polyethylene THA.

Conclusion

Controversy regarding the recall of the ASR (DePuy) resurfacing prosthesis and in relation to trunnion related failures of large head MoM prostheses have generated a great deal of uncertainty. A recent medical device alert from the Medicines and Healthcare products Regulation Agency (MHRA)³⁹ recommends investigation in all symptomatic patient with blood metal ion levels and imaging using a metal artifact reduction sequence (MARS) MRI scan. A repeat blood test should be performed at three months to see the trend and if this is increasing and/or imaging suggests soft-tissue damage then revision should be considered. Follow-up should be annual for at least five years in the case of MoM resurfacing and stemmed MoM total hip arthroplasty with femoral head diameter < 36 mm. In stemmed MoM THA with femoral head diameter of > 36 mm and Depuy ASR, both asymptomatic and symptomatic

patients should have blood metal ion levels measured. If these are above 7 ppb then a second blood test should be taken three months later. Imaging is then recommended and revision must be considered. These patients must be followed up at least annually for the life of the prosthesis.

The facts remain that devices that preserve bone stock, facilitate later revision and potentially allow better functional recovery are attractive. Metal-on-metal (MoM) hip resurfacing arthroplasty and 28 mm /32 mm MoM THA with proven designs remain a good option in well-selected patients with appropriate anatomy under the care of experienced and skilled surgeons. The results of the 28 mm /32 mm MoM THA are similar to metal-on-polyethylene at ten years but do not offer the other advantages ascribed to hip resurfacing.

Our knowledge of MoM bearings and their behaviour is evolving rapidly. There are currently major question marks over large head MoM THA. However, current data suggests that appropriate surgical technique for hip resurfacing in an appropriately selected cohort of patients using appropriate implants is associated with a low incidence of adverse soft-tissue reactions and good functional outcomes. We must be careful not to “throw out the baby with the bathwater”.

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References

1. Wroblewski BM, Fleming PA, Siney PD. Charnley low-frictional torque arthroplasty of the hip: 20-to-30 year results. *J Bone Joint Surg [Br]* 1999;81-B:427–430.
2. Anissian HL, Stark A, Gustafson A, Good V, Clarke IC. Metal-on-metal bearing in hip prosthesis generates 100-fold less wear debris than metal-on-polyethylene. *Acta Orthop Scand* 1999;70:578–582.
3. Fisher J, Jin Z, Tipper J, Stone M, Ingham E. Tribology of alternative bearings. *Clin Orthop Relat Res* 2006;453:25–34.
4. Treacy RB, McBryde CW, Pynsent PB. Birmingham hip resurfacing arthroplasty. A minimum follow-up of five years. *J Bone Joint [Br]* 2005;87-B:167–170.
5. Back DL, Dalziel R, Young D, Shimmin A. Early results of primary Birmingham hip resurfacing: an independent prospective study of the first 230 hips. *J Bone Joint Surg [Br]* 2005;87-B:324–329.
6. Malviya A, Holland JP. Pseudotumours associated with MoM hip resurfacing: 10-year Newcastle experience. *Acta Orthop Belg* 2009;75:477–483.
7. Kwon YM, Thomas P, Sumner B, et al. Lymphocyte proliferation responses in patients with pseudotumors following MoM hip resurfacing arthroplasty. *J Orthop Res* 2010;28:444–450.
8. Anderson H, Toms AP, Cahir JG, et al. Grading the severity of soft tissue changes associated with MoM hip replacements: reliability of an MR grading system. *Skeletal Radiol* 2011;40:303–307.
9. No authors listed. Medical Device Alert: All metal-on-metal (MoM) hip replacements (MDA/2012/008). <http://www.mhra.gov.uk/Publications/Safetywarnings/MedicalDeviceAlerts/CON143782> (last accessed 16 August 2012).
10. Amstutz HC, Ebrahmdadeh E, Sarkany A, Le Duff M, Rude R. Preservation of bone mineral density of the proximal femur following hemisurface arthroplasty. *Orthopedics* 2004;27:1266–1271.
11. Daniel J, Pynsent PB, McMinn DJ. Metal-on-metal resurfacing of the hip in patients under the age of 55 years with osteoarthritis. *J Bone Joint Surg [Br]* 2004;86-B:177–188.
12. Amstutz HC, Grigoris P, Dorey FJ. Evolution and future of surface replacement of the hip. *J Orthop Sci* 1998;3:169–186.
13. Ward P. Heavy metal is hip again. *Daily Telegraph* 29 June 1999;1495.
14. NICE guidelines. The indications for hip resurfacing, June 2002. <http://guidance.nice.org.uk/TA44> (date last accessed 17 August 2012).

15. **Jameson SS, Langton DJ, Nargol AV.** Articular surface replacement of the hip: a prospective single-surgeon series. *J Bone Joint Surg [Br]* 2010;92-B:28–37.
16. **No authors listed.** National Joint Registry for England and Wales: 8th Annual report, 2011. <http://www.njrcentre.org.uk> (date last accessed 16 August 2012).
17. **Berton C, Girard J, Krantz N, Migaud H.** The Durom large diameter head acetabular component: early results with a large-diameter metal-on-metal bearing. *J Bone Joint Surg [Br]* 2010;92-B:202–208.
18. **Langton DJ, Jameson SS, Joyce TJ, et al.** Early failure of metal-on-metal bearings in hip resurfacing and large diameter total hip replacement: a consequence of excess wear. *J Bone Joint Surg [Br]* 2010;92-B:38–46.
19. **Langton DJ, Joyce TJ, Jameson SS, et al.** Adverse reaction to metal debris following hip resurfacing: the influence of component type, orientation and volumetric wear. *J Bone Joint Surg [Br]* 2011;93-B:164–171.
20. **de Steiger RN, Hang JR, Miller LN, Graves SE, Davidson DC.** Five-year results of the ASR XL Acetabular System and the ASR Hip Resurfacing System: an analysis from the Australian Orthopaedic Association National Joint Replacement Registry. *J Bone Joint Surg [Am]* 2011;93-A:2287–2293.
21. **No authors listed.** NHS Supply Chain: ODEP. <http://www.supplychain.nhs.uk/odep/> (date last accessed 16 August 2012).
22. **Glyn-Jones S, Pandit H, Kwon YM, et al.** Risk factors for inflammatory pseudotumour formation following hip resurfacing. *J Bone Joint Surg [Br]* 2009;91-B:1566–1574.
23. **McBryde CW, Theivendran K, Thomas AM, Treacy RB, Pynsent PB.** The influence of head size and sex on the outcome of Birmingham hip resurfacing. *J Bone Joint [Am]* 2010;92-A:105–112.
24. **Prosser GH, Yates PJ, Wood DJ, et al.** Outcome of primary resurfacing hip replacement: evaluation of risk factors for early revision. *Acta Orthop* 2010;81:66–71.
25. **Johnson AJ, Zywielski MG, Hooper H, Mont MA.** Narrowed indications improve outcomes for hip resurfacing arthroplasty. *Bull NYU Hosp Jt Dis* 2011;69(Suppl):27–29.
26. **De Haan R, Pattyn C, Gill HS, et al.** Correlation between inclination of the acetabular component and metal ion levels in metal-on-metal hip resurfacing replacement. *J Bone Joint Surg [Br]* 2008;90-B:1291–1297.
27. **Bow JK, Rudan JF, Grant HJ, Mann SM, Kunz M.** Are hip resurfacing arthroplasties meeting the needs of our patients? A 2-year follow up study. *J Arthroplasty* 2012;27:984–989.
28. **Grammatopoulos G, Pandit H; Oxford Hip and Knee Group, Murray DW, Gill HS.** The relationship between head-neck ratio and pseudotumour formation in metal-on-metal resurfacing arthroplasty of the hip. *J Bone Joint Surg [Br]* 2010;92-B:1527–1534.
29. **Grammatopoulos G, Pandit H, Glyn-Jones S, et al.** Optimal acetabular orientation for hip resurfacing. *J Bone Joint Surg [Br]* 2010;92-B:1072–1078.
30. **Schmalzreid TP, Peters PC, Maurer BT, Bragdon CR, Harris WH.** Long-duration metal-on-metal total hip arthroplasties with low wear of the articulating surface. *J Arthroplasty* 1996;11:322–331.
31. **Crowninshield RD, Maloney WJ, Wentz DH, Humphrey SM, Blanchard CR.** Biomechanics of large femoral heads: what they do and don't do. *Clin Orthop Relat Res* 2004;429:102–107.
32. **Garbuz DS, Tanzer M, Greidanus NV, Masri BA, Duncan CP.** The John Charnley Award: metal-on-metal hip resurfacing versus large diameter head metal-on-metal total hip arthroplasty: a randomized clinical trial. *Clin Orthop Relat Res* 2010;468:318–325.
33. **Langton DJ, Jameson SS, Joyce TJ, et al.** Accelerating failure rate of the ASR total hip replacement. *J Bone Joint Surg [Br]* 2011;93-B:1011–1016.
34. **Smith AJ, Dieppe P, Vernon K, Porter M, Blom A.** Failure rates of stemmed metal-on-metal hip replacements: analysis of data from the National Joint Registry of England and Wales. *Lancet* 2012;379:1199–1204.
35. **Eswaramoorthy V, Moonot P, Kalairajah Y, Biant LC, Field RE.** The Metasul metal-on-metal articulation in primary total hip replacement: clinical and radiological results at ten years. *J Bone Joint Surg [Br]* 2008;90-B:1278–1283.
36. **Sharma S, Vassan U, Bhamra MS.** Metal-on-metal total hip joint replacement: a minimum follow-up of five years. *Hip Int* 2007;17:70–77.
37. **Saito S, Ishii T, Mori S, et al.** Long-term results of metasul metal-on-metal total hip arthroplasty. *Orthopedics* 2010;33:..
38. **Randelli F, Banci L, D'Anna A, Visentin O, Randelli G.** Cementless Metasul metal-on-metal total hip arthroplasties at 13 years. *J Arthroplasty* 2012;27:186–192.
39. **No authors listed.** Medicines and Healthcare products Regulatory Agency: medical device alert: all metal-on-metal (MoM) hip replacements, 2010 (MDA/2012/008). <http://www.mhra.gov.uk/home/groups/dts-bs/documents/medicaldevicealert/con143787.pdf> (date last accessed 16 August 2012).