Guest editorial

Hip resurfacing: expectations and limitations

The first hip resurfacing arthroplasty (HRA) was performed by Smith-Petersen (1939) in 1923. He temporarily interposed a thin hemispherical shell between the femoral head and acetabulum in patients with arthrosis. He expected new cartilage to grow on the articular surfaces and called his technique two-stage mold arthroplasty. Originally, the shells were made of glass, bakelite, or celluloid. In 1938, he changed to metal shells made of a recently developed cobalt-chrome-molybdenum alloy. He discovered that it was not cartilage that grew beneath the shell but fibrous tissue. He also discovered that leaving the shell in situ gave better clinical results than removing the shell. These shells were used up until the late 1950s, by which time the first intramedullary prosthetic stems had entered the market. (See also Northover and Maqsood (2008) in this issue of Acta).

In the 1970s, the second generation of resurfacings were developed. They were total resurfacings with a metal-on-polyethylene bearing. The most well-known design was the Wagner double cup. It consisted of a cemented metal or ceramic femoral shell and a cemented all-polyethylene acetabular component. The clinical results were disappointing. Howie et al. (1990) reported only 40% survival at 8-year follow-up for the Wagner double cup and Amstutz et al. (1986) found 53% survival at 7 years for the THARIES resurfacing prosthesis. These implants failed from osteolysis and aseptic loosening. The cause of failure was thought to be either polyethylene wear, stress shielding, or avascular necrosis. In retrospect, these failures can be mainly attributed to cytokine-mediated osteolysis induced by wear particles from the thin-walled polyethylene acetabular component (Harris 1994).

Recognizing this problem, McMinn and Treacy in Birmingham in the 1990s developed the third generation of resurfacings with a metal-on-metal bearing. After clinical trial and error, the best fixation was obtained with a cemented, stemmed femoral hemispherical shell and a conventional HA-coated Co-Cr-Mo cup. In 1994, implantation of this McMinn prosthesis was started, to be followed in 1996 by the Conserve Plus designed by Amstutz. When favorable clinical results were reported (Daniel et al. 2004), many other companies followed with designs that all had the same basic features as the McMinn prosthesis. By now, at least 15 types of resurfacing prosthesis are available, and the number is still increasing. These prostheses differ in many details, such as shape, sizing, head coverage, clearance, metal alloy used, heat treatment, instrumentation, and so on. Just as with conventional hips, they exhibit differences in clinical outcome. The Swedish and Australian registries have listed a two- to threefold difference in revision rate between different makes (Swedish Hip Arthroplasty Register 2006, Australian Orthopaedic Association 2007).

Advocates of resurfacing claim that there are a number of advantages of HRA over conventional total hip arthroplasty (THA), e.g. less bone removal, restoration of anatomical hip center, physiological loading, higher postoperative activity levels, excellent survival rates, and ease of revision. These advantages appeal strongly to the imagination of both surgeons and patients. Over a short period of time, resurfacings became very popular and the number of implantations rose to about 10% of all primary hip replacements in countries such as the UK, Australia, and the Netherlands (National Joint Registry for England and Wales 2006, Australian Orthopaedic Association 2007). In Sweden, where the choice of implant is based more on clinical evidence from the hip register, the number of resurfac-

DOI 10.1080/17453670810016777

ings is only 1% (Swedish Hip Arthroplasty Register 2006). In 2004, the designers of the McMinn and BHR resurfacing prosthesis published excellent medium-term results (Daniel et al. 2004) with 1 revision in 446 resurfacings with a mean follow-up of 3 (0–8) years. Publications from designers, however, often present results that are better than those from multicenter studies. Survival rates in multicenter studies have shown worse results for HRA than for THA. The National Joint Registry for England and Wales (2006) has reported revision rates of 2.4% for HRA and 0.9% for cemented THA at 3 years; the Australian Orthopaedic Association (2007) has reported 4.4% revision for HRA and 3.1% revision for cemented THA at 5 years; and the Oswestry registry has reported a revision rate of 4.6% for HRA at 7 years (Kahn et al. 2008). In the Australian registry, the revision risk ratio, adjusted for age and sex, for HRA and THA is 1.4. Main reasons for revision are neck fractures (occurring in 1–2% of resurfacings), loosening, and pain.

In the literature a variety of other complications related to HRA can be found, including metallosis, raised metal ion levels, aseptic lymphocytic vasculitis associated lesions (ALVAL), pseudotumors, clicking, squeaking, and nerve palsy (Back et al. 2005, Lachiewicz 2007). Mabilleau et al. (2008) give in this issue of Acta an overview of the literature on biological responses to metal-on-metal HRA. They found an increasing number of case reports on periprosthetic soft-tissue masses and osteolysis as a response to elevated metal ion levels. The increased concentration of metal particles in the joint space of HRA could lead to a T lymphocyte-mediated hypersensitivity reaction (Type IV). The authors express their concerns about the risks of long-term exposure to metal ions. An increased risk of developing lymphoma in patients with chronic inflammatory disease who undergo metal-on-metal orthoplasty has recently been considered (Lidgren 2008).

Various claimed advantages of HRA like less bone removal and better range of motion can be seriously questioned.

Loughead et al. (2006) found it necessary to use a considerably larger cup diameter for HRA than for THA. Patients with large femoral head diameters required a 5-mm larger acetabular reamer for HRA than for THA, which means 15 cm^3 more acetabular bone removal. In response, Muirhead-Allwood et al. (2006) and Vendittoli (2006) stated that the same acetabular cup diameter could be used for HRA and THA. A small survey done among the largest distributors in the Netherlands showed that the most frequently sold cup diameters were 52–54 for THA and 58–60 for HRA (Spierings, unpublished data). In general practice, HRA presumably does lead to the use of 6-mm larger cup diameters on average, which requires removal of a great deal of the acetabular bone stock. This excessive bone loss results in a thin acetabular wall, which will complicate revision if it is necessary.

The range of motion in HRA is clearly compromised. The head/neck diameter ratio for a resurfacing is in the order of 1.4, as compared to 2.3 for a THA. In this issue of Acta, Kluess et al. (2008) have analyzed the range of motion of 8 different HRA models in a CAD model derived from CT scans. In all cases, HRA flexion was reduced to less than 90° and the average range of motion was reduced by 31° to 48° below the range of motion of THA. This makes HRA prone to impingement and subluxation. Bengs et al. (2008), also in this issue of Acta, analyzed 8 hip resurfacing designs implanted into adult composite femurs and pelvises. They found with their designs a less range of motion than with conventional arthroplasty. Neck impingement was common with resurfacing which raises the concern for component loosening and femoral neck fracture.

Easy resurfacing arthroplasties do not exist; even in experienced hands, it remains a difficult procedure. In particular, component positioning and cementing technique are critical factors—and the main causes of failure in retrieval studies. The main reason for early revision is fracture of the neck arising from the edge of the implant, which can be initiated by uncovered reamed bone and notching. Early revisions were more common in older patients and females, and bone quality seemed to be a critical factor. Late revisions were without fracture and most of them showed signs of wear and rim loading, which can be related to malpositioning.

HRA is critical for malpositioning of both the femoral and the acetabular component. Notching of the femoral component is a contributory factor

in the high incidence of neck fracture in HRA patients. Varus placement of the femoral component leads to higher levels of stress and increases the probability of failure (Radcliffe et al. 2007, Beaulé et al. 2004, see also Lazarinis et al. (2008) in this issue of Acta). Cup anteversion greater than 25% or cup abduction less than 45% can result in impingement and increased wear. The safe zone for cup and head positioning is smaller in HRA than in THA, and deviations are less forgiving.

Severe stress shielding associated with resurfacing is already known from the second-generation resurfacings (Head 1984). Finite element analysis warn for the effects of stress shielding and osteopaenia beneath the femoral shell (Ong et al. 2006). In particular if the stem is bonded it will transmit most of the joint forces through the tip of the stem. The stress-shielded neck will remodel, and bone loss can be expected as a consequence. In the long term, this may be visible on radiographs as neck thinning, but most of the bone resorption will be overprojected by the femoral component. Neck thinning is found in most HRA cases. Hing et al. (2007) measured more than 10% thinning in 28% of his patients. As patients age and premenopausal women become postmenopausal, further adverse bone remodeling may be expected beneath the femoral head. Thus, neck fracture is not only a short-term complication but also a long-term risk.

Patient selection is critical in HRA. The Australian registry shows high HRA revision rates for women of all ages and for men over 65 years Australian Orthopaedic Association (2007). Young, active men have the best bone stock, which makes them perform best in HRA, but the same subgroup performs worst in THA. Despite this finding, the survival of THA is still better than the survival of HRA in this subgroup. Even within this subgroup, patient selection remains critical for the outcome of HRA (Schmalzried et al. 2005). According to Eastaugh-Waring et al. (2006), less than 50% of the THA patients under 50 qualify for an HRA. Reasons for unsuitability include collapse and cystic degeneration of the femoral head. According to Lachiewics (2007) only 6% of all THA patients are indicated for HRA.

Contraindications also include low bone density, osteonecrosis, varus neck-shaft angle, small component size, low head offset, leg length discrepancy, use of glucocorticosteroids, endocrine disorders, malabsorption, and alcohol abuse. Based on medium-term results only, the combination of experienced surgeons who perform this procedure on a regular basis, a very limited group of tall, young, active male patients with good bone stock, and a limited number of HRA designs might qualify for this procedure. However, even with these precautions the advantages of resurfacing are limited. Short- and medium-term revision rates in multicenter studies are unacceptably high (National Joint Registry for England and Wales 2006, Swedish Hip Arthroplasty Register 2006, Australian Orthopaedic Association 2007) and there is a lack of long-term results. Long-term complications are to be expected. The advantages of resurfacing, such as preservation of femoral bone stock and the potential for easy femoral revision (the outcome of which has never been reported) are outbalanced by the disadvantages such as acetabular bone loss, neck stress shielding, reduced range of motion, and a higher medium-term revision rate. For the moment, large-scale use of these implants cannot be justified. The simple fact of legislation of a new type of prosthesis does not mean that it is better or even comparable to those already on the market. Clinical trials with a very limited number of patients and a follow-up of only a few months is sufficient to obtain CE marking for class III medical devices. Although companies heavily promote resurfacing implants and suggest that patients can enter into vigorous sporting activities, it is the responsibility of the surgeon to protect the patient from false expectations. Patients are best served with proven designs that have proven long-term outcome. Many national registries now provide an abundant amount of objective clinical data. Why not use them? In the future, if long-term follow-up studies show an HRA survival rate that is superior to that of THA then HRA might become a valuable tool for a selected group of patients and surgeons. Until that time, resurfacing remains an experimental design for investigational use only.

Pieter T. J. Spierings
Madoerastraat 24, NL-6524 LH Nijmegen, the Netherlands
pspierings@spierings.biz

Amstutz H C, Dorey F, O'Carroll P F. THARIES resurfacing arthroplasty. Clin Orthop 1986; (213): 92-114.

Australian Orthopaedic Association, National Joint Replacement Registry, Annual Report 2007. www.aoa.org.au/jointregistry_pub.asp.

Back D L, Dalziel R, Young D, Shimmin A. Early results of primary Birmingham hip resurfacings. J Bone Joint Surg (Br) 2005; 87 (3): 324-9.

Beaulé P E, Lee J L, Le Duff M J, Amstutz H C, Ebramzadeh E. Orientation of the femoral component in surface arthroplasty of the hip. J Bone Joint Surg (Am) 2004; 86 (9): 2015-21.

Bengs B C, Sangiorgio S N, Ebramzadeh E. Less range of motion with resurfacing arthroplasty than with total hip arthroplasty. In vitro examination of 8 designs. Acta Orthop 2008; 79: 755-62.

Daniel J, Pynsent P B, McMinn D J W. Metal-on-metal resurfacing of the hip in patients under the age of 55 years with osteoarthritis. J Bone Joint Surg (Br) 2004; 86 (2): 177-84.

Eastaugh-Waring S J, Seenath S, Learmonth D S, Learmonth I D. The practical limitations of resurfacing hip arthroplasty. J Arthroplasty 2006; 21 (1): 18-22.

Harris W H. Osteolysis and particle disease in hip replacement. A review. Acta Orthop Scand 1994; 65 (1): 113-23.

Head W C. Total articular resurfacing arthroplasty. J Bone Joint Surg (Am) 1984; 66 (1): 28-34.

Hing C B, Young D A, Dalziel R E, Bailey M, Back D L, Shimmin A J. Narrowing of the neck in resurfacing arthroplasty of the hip. J Bone Joint Surg (Br) 2007; 89 (8): 1019-24.

Howie D W, Campbell D, McGee M, Cornish B L. Wagner resurfacing hip arthroplasty. J Bone Joint Surg (Am) 1990; 72 (5): 708-14.

Khan M, Kuiper J-H, Edwards D, Robinson E, Richardson J B. Birmingham Hip Arthroplasty. Five to eight years of prospective multicenter results. J Arthroplasty 2008 (in press).

Kluess D, Zietz C, Lindner T, Mittelmeier W, Schmitz K-P, Bader R. Limited range of motion of hip resurfacing arthroplasty due to unfavorable ratio of prosthetic head size and femoral neck diameter. Acta Orthop 2008; 79: 748-54.

Lachiewicz P F. Metal-on-metal hip resurfacing. A sskeptic's view. Clin Orthop 2007; (465): 86-91.

Lazarinis S, Milbrink J, Hailer N P. Avascular necrosis and subsequent femoral neck fracture 3.5 years after hip resurfacing: a highly unusual late complication in the absence of risk factors—a case report. Acta Orthop 2008; 79: 763-8.

Lidgren L. Chronic inflammation, joint replacement and malignant lymphoma. J Bone Joint Surg (Br) 2008; 90: 7-10.

Loughead J M, Starks I, Chesney D, Matthews J N S, McCaskie A W Holland J P. Removal of acetabular bone in resurfacing arthroplasty of the hip. J Bone Joint Surg (Br) 2006; 88 (1): 31-4.

Mabilleau G, Kwon Y-M, Pandit H, Murray D W, Sabokbar A. Metal-on-metal hip resurfacing arthroplasty. A review of periprosthetic biological reactions. Acta Orthop 2008; 79: 734-7.

Muirhead-Allwood S K, Patel C, Mohandas P. Removal of acetabular bone in resurfacing arthroplasty of the hip. J Bone Joint Surg (Br) 2006; 88 (8): 1117.

National Joint Registry for England and Wales, 4th Annual Report 2006-2007. www.njrcentre.org.uk

Northover J R, Maqsood M. 58-year follow-up of a vitallium mold hip arthroplasty. A case report and literature review. Acta Orthop 2008; 79: 731-3.

Ong W L, Kurtz S M, Manley M T, Rushton N, Mohammed N A, Field R E. Biomechanics of the Birmingham hip resurfacing arthroplasty. J Bone Joint Surg (Br) 2006; 88 (8): 1110-5.

Radcliffe I A J, Taylor M. Investigation into the effect of varus-valgus orientation on load transfer in the resurfaced femoral head: A multi-femur finite element analysis. Clin Biomechanics 2007; 22: 780-6.

Schmalzried T P, Silva M, de la Rosa M A, Choi E-S, Fowble V A. Optimizing patient selection and outcomes with total hip resurfacing. Clin Orthop 2005; (441): 200-4.

Smith-Petersen M N: Arthroplasty of the hip. J Bone Joint Surg 1939; XXI (2): 269-88.

Swedish Hip Arthroplasty Register, Annual Report 2006. www.jru.orthop.gu.se

Vendittoli P-A, Lavigne M, Girard J, Roy A G. A randomized study comparing resection of acetabular bone at resurfacing and total hip replacement. J Bone Joint Surg (Br) 2006; 88 (8): 997-1002.