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Birmingham Hip Resurfacing Arthroplasty: Short-term Clinical and Radiographic Outcome

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Abstract
Background: Aim of our study was to evaluate the clinical and radiographic outcome of the first 300 consecutively implanted Birmingham Hip Resurfacing arthroplasties (BHR) in our department.
Methods: 300 BHR arthroplasties were performed in 263 patients until May 2003. Primary clinical endpoints of the investigation were the implant survival and the total Harris hip score, assessed at the last examination.
Results: At a median follow-up time of 24 months the Kaplan/Meier survivor estimate was 98%. 6 implant revisions were performed due to infection (2), malposition (1), femoral neck fracture (1), primary unstable cup (1) and chronic pain (1), respectively. The median Harris hip score improved from 51 points to 96 points at last follow-up. No hip showed radiographic signs of aseptic implant loosening.
Conclusions: The preliminary experience with the BHR for the younger adult requiring hip arthroplasty is encouraging, but has to be reproduced in the long-term.

Key words: hip replacement, hip resurfacing, Birmingham Hip Resurfacing

Introduction

The concept of resurfacing of the hip is not new and may be referred to some of the very early designs of hip arthroplasty such as the ivory hip, the Judet prosthesis and the Smith-Petersen cup. In the seventies and early eighties metal-on-polyethylene devices were used, but the results of these implants were found to be rather poor. (Furuya et al. 1978, Wagner 1978, Freeman and Bradley 1983) Therefore enthusiasm for resurfacing disappeared, although it was felt that the root of the problem had been the materials and operation technique without guiding instruments rather than the concept itself. (Wagner 1978, Bell et al. 1985, Howie et al. 1990, Freeman 1994, Paul 1998)

After the renaissance of metal-on-metal bearings in the eighties, the concept was re-introduced. After several pilot studies with different metal-on-metal hip resurfacing prototypes, the Birmingham hip resurfacing (BHR) arthroplasty (Midland Medical Technologies Ltd, Birmingham, UK) became available in 1997. (McMinn et al. 1996, McMinn 2003)

We started to implant metal-on-metal hip resurfacings in 1998 and have critically evaluated the outcome of our consecutive series of the first 300 hips implanted with the BHR.

Patients and Methods

Patient Cohort

This study comprised 300 consecutive BHR implantations in 263 patients, who underwent hip resurfacing arthroplasty between September 1998, and March 2003, with a median age of 49 years (range 15-69 years). 43% of the patients were female. The demographic characteristics of the patients are shown in Table I, and the etiology of the disease is shown in Table II. In average 19% (2%-32% per year) of all primary total hip arthroplasties during that time period were performed as surface replacements. Our initial criteria for consideration for a BHR were the same as for total hip replacement (THR); pain, limp, contracture and limitation of daily living. Patients were considered for a BHR if they were active and younger than 50 years. Outside this age group patients were considered for BHR on an individual basis. Contraindications to performing a BHR included osteopenia, as classified by the Singh index, allergy to contents of the alloy and evidence of renal impairment. (Krischak et al. 1999) Relative contraindications were identified on an individual basis. Patients with abnormal femoral (coxa vara) or acetabular anatomy (DDH) and poor femoral or acetabular bone stock were assessed both radiographically and intra-operatively as to their suitability for surface replacement. Large cysts and necrotic areas which compromised the femoral bone stock were either graphted with spongiosa taken from the reamers or surgery was converted to a THR intra-operatively. In cases of developmental dysplasia hip resurfacing was performed if the acetabular defect and the remaining femoral deformity did not compromise primary stable implantation and hip biomechanics. If a stable implantation seemed not possible or a free range of motion seemed not achievable, surgery was converted in a THR intraoperatively. Operative consent was fully informed and included issues of metal ion levels, risk of femoral neck fracture, revision options and routine aspects of hip arthroplasty.

Table I. Demographic data of 263 patients (300 hips) after total hip replacement; distribution characteristics are absolute and relative (%) frequencies for categorical data and medians (in brackets first – third quartile and minimum – maximum observation).

Characteristic	absolute (relative %) frequency median (interquartile range {total range})
total number of arthroplasties	
in female patients	130 (43%)
in male patients	170 (57%)
age at time of surgery (years)	
female patients	49 (44-55 {28, 65})
male patients	49 (45-56 {15, 69})
weight (kg)	
female patients	70 (62-80 {42, 115})
male Patients	85 (80-95 {44, 140})
height (cm)	
female patients	165 (160-168 {150, 187})
male patients	178 (173-182 {160, 198})
body mass index (kg/m2)	
female patients	25.4 (23.1-29.3 {15.4, 40.8})
male patients	27.4 (25.5-29.4 {16.8, 41.2})
Charnley classification (no. of hips)	
class A	177 (59.0%)
class B	81 (27.0%)
class C	42 (14.0%)

Table II. absolute and relative frequencies (%) of etiological disease classifications for 300 hips (263 patients).

etiology of the disease	absolute and relative (%) frequency
developmental dysplasia	177 (59%)
Crowe class I	141 (47%)
Crowe class II	36 (12%)
others	
osteoarthritis	57 (19%)
osteonecrosis Ficat stage IV	27 (9%)
slipped capital femoral epiphysis	15 (5%)
protrusio acetabuli	12 (4%)
posttraumatic arthritis	8 (3%)
postinflammatoric arthritis	3 (1%)
arthritis after synovitis villonodosa	1 (0.3%)
underwent previous operations	72 (24%)
osteotomy	46
osteosynthesis	7
forage	3
others	16

Surgical Technique

Surgery was performed under hypotensive general anesthesia using an extended southern approach in a lateral position. In 47 DDH cases (16%) the Dysplasia cup was used and the remaining superolateral acetabular defect filled with cancellous bone taken from the reamers and the excised sections of the head. The cancellous bone was covered with parts of labrum or capsular tissue. In 45 cases with hip protrusion (15%) cancellous bone was impacted into the acetabular ground. The femoral component was oriented in a slight valgus alignment and implanted after thorough bone cleaning with a pulse lavage device and under intraosseous suction (canula drilled into the lesser trochanter). Simplex low-viscosity cement with 1g tobramycine per pack (Howmedica International, Limerick, Ireland) was used in all operations. Preoperatively, all patients received one dose of an intravenous cephalosporin. The total of 300 operations was performed by 8 surgeons under supervision of a senior staff member (WCW). Median Surgical time was 120 (range 58 – 216) minutes.

Postoperative Management

Low molecular heparin (0.2-0.6 ml fraxiparine per day, weight-adapted, GlaxoSmithKline GmbH, Germany) was used for thromboprophylaxis until re-mobilization, at least for 3 weeks. Diclophenac, indometacin or ibuprofen was used on an individual basis in 261 cases (87%) in order to prevent the formation of heterotopic bone. In 2002 we started with a routine protocol of 150mg diclophenac per day over 3 weeks. Walking practice was started on the first postoperative day, with full weight-bearing allowed except in cases with acetabular grafting in which partial weight-bearing was recommended during the first 6 weeks. During the first 6 weeks hip flexion was limited to 90° and forced internal rotation was not allowed. Sporting activities were not allowed until 3 months after surgery.

Outcome Evaluation

Patients were prospectively investigated pre- and postoperatively, at 6 weeks, 3, 6, 12 months and annually thereafter. Examination at last follow-up was done by an independent observer (MA). Intra- and postoperative medical and surgical complications were recorded. Patient characteristics were documented including age, gender, diagnosis and previous hip surgery. Pain, function and range of motion were evaluated using the Harris hip-rating system. (Harris 1969) Leg-length discrepancy was assessed by means of blocks with different thicknesses which were placed under the patient's foot until the pelvis leveled.

Radiographic Analysis

All patients had anteroposterior radiographs of the pelvis taken preoperatively and at each follow-up. Radiographs were studied by an independent observer (MA). Component position was analyzed using the abduction angle of the cup and the postoperative stem-shaft angle in comparison to the preoperative neck-shaft angle. Heterotopic ossification was graded according to the Brooker classification. (Brooker et al. 1973). Acetabular radiolucencies were identified in the three Charley zones. (Charnley 1972) Fixation of the femoral component was investigated by identifying radiolucencies around the metaphyseal stem in 3 zones. (Amstutz et al. 2004)

Primary Clinical Endpoints

The primary clinical endpoints of this investigation were the total Harris Hip score (0 – 100 points) at the last individual follow-up visit and the individual time to implant failure or loss to follow-up (months).

Secondary Clinical Endpoints

The most important secondary clinical endpoints were the occurrence patterns of radiographic signs of implant loosening (complete radiolucency line and/or component migration) and the individual Harris Hip score profiles over time.

Statistical Analysis

All numerical and graphical evaluations were performed by an independent biometrician (FK) by means of the software SPSS (release 12.0 for Windows).

Sample size calculation was based on the intention to estimate the median Harris Hip Score at final recall assuming a standard deviation of 20 points with a maximum confidence interval length of 5 points at a 99% confidence level. These assumptions implied a minimum sample size of 295 implantations to be recruited. Data description was based on medians and quartiles for continuous endpoints and on absolute and relative frequencies for categorical endpoints. Comparisons of repeated measurements in continuous endpoints (such as the total Harris Hip score) were evaluated by means of intra-individual differences. The graphical representation of continuous data was based on nonparametric box whisker plots, accordingly. Time to implant failure data was analysed by means of the Kaplan/Meier method (software SPSS 12.0 for windows). For significance comparisons in continuous repeated measurements, the sign test was applied, and the two sample Wilcoxon / multi sample Kruskal/ Wallis test for group comparisons along continuous endpoints. Due to the small number of implant failures, no significance tests were applied to the time to failure data. Results of significance tests were summarized by means of p-values; the latter were not adjusted for multiplicity due to the exploratory character of this investigation; a p-value < 0.05 therefore indicates local statistical significance.

Results

Clinical Outcome

The median duration of clinical and radiographic follow-up was 24 months (2 – 66 months, interquartile range 14 – 36). Two patients were lost to follow-up. One patient died from unrelated cause without revision. The other patient was converted in a THR due to infection in a different hospital. This results in a follow-up rate of 99.3% at last recall. But not all patients were available for each assessment time between surgery and last recall (Fig. 1).

The patients' Harris hip score profiles are summarized in Table III after stratification for their postoperative Charnley classification. The median total Harris hip score of the total patient sample improved from 51 points (44 – 60 points) before surgery to 96 points (85 – 100 points) at their latest individual follow-up assessment (sign test $p<0.001$). The median total range of motion improved in all patients from 140° (105° – 165°) pre-operatively to 230° (200° – 255°) at their latest assessment point. An association was found between the Charnley classification and the increase in the total Harris hip score: The median score among patients with Charnley class C involvement rose from 46 to 82 points (70 – 92 points), which was inferior to that for both patient samples with Charnley class A and class B involvement, where the median score changed from 53 to 98 and 49 to 94, respectively ($p=0.000$). Clinical results assessed by the Harris hip score improved clinically relevant during the first 6

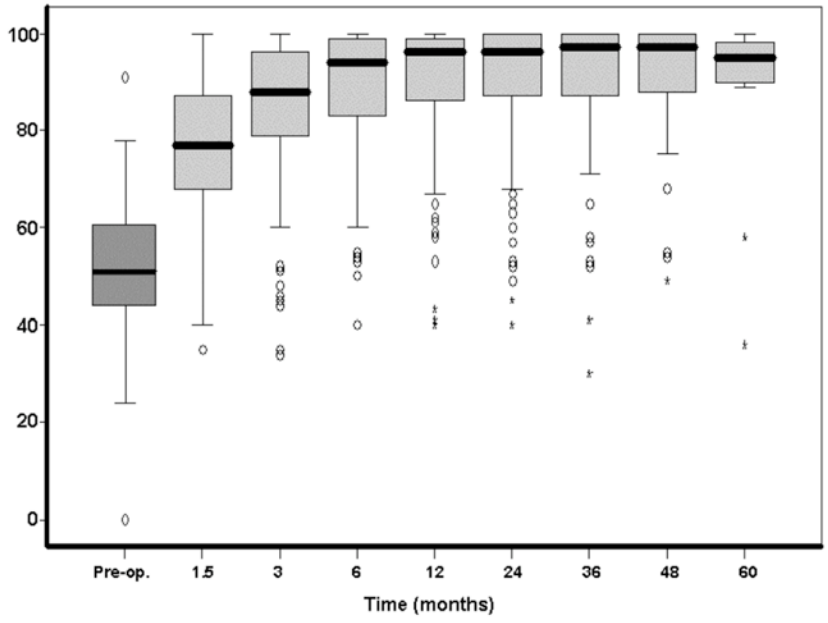

Fig. 1. Nonparametric box plots for the Harris hip total score profile at subsequent assessment times (1.5, 3, 6, 12, 24, 36, 48, 60 months) after implantation of a BHR: horizontals display medians and quartiles, circles / asterisks indicate statistical outliers / extreme values with more than twice / thrice deviation of the interquartile range from the lower quartile.

Table III. distribution characteristics of Harris Hip total and sub scores (pain, movement and function) assessed before total hip replacement and at latest individual recall time, stratified for the underlying hip's Charnley classification: medians (in brackets first – third quartile and minimum – maximum observation).

Charnley category	No. of hips	pain score	movement score	function score	total score
A					
preop	179	20 (10-20 {10; 40})	7 (7-8 {4; 9})	31 (27-34 {8; 43})	53 (45-61 {27, 91})
latest	172	44 (40-44 {10; 44})	9 (8-9 {5; 9})	47 (44-47 {16; 47})	98 (94-100 {36; 100})
B					
preop.	80	10 (10-20 {10; 30})	7 (6-7 {3; 9})	29 (25-33 {8; 44})	49 (43-57 {24; 72})
latest	81	44 (40-44 {20; 44})	9 (8-9 {4; 9})	44 (37-47 {29; 47})	94 (80-98 {55; 100})
C					
preop.	41	10 (10-20 {10; 20})	7 (7-8 {5; 9})	28 (23-32 {11; 44})	46 (41-56{26; 72})
latest	46	30 (30-44 {10; 44})	9 (8-9 {7; 9})	39 (31-44 {11; 47})	82 (70-92 {30; 100})

months after surgery; after the 6 month follow-up no further notable increase was found (Fig.1). Whereas 136 patients (45%) showed positive or indifferent Trendelenburg signs before surgery, only 17 patients (6%) did so at their latest follow-up examination.

Leg-Length Discrepancy

103 patients (31% of all hips) had a leg-length discrepancy > 0.5 cm before surgery; the discrepancy was ≥2 cm in 30 patients. After surgery 82 patients (27% of all hips) had a leg-length discrepancy > 0.5 cm, but only 10 patients > 2 cm.

Radiographic Results

A total of 298 complete sets of radiographs could be evaluated. The incomplete sets of the two patients, lost to follow-up had at least one radiograph taken postoperatively and were included when appropriate.

Heterotopic Bone Formation

Heterotopic ossification was present in 76 hips (25%). The majority of the cases, 52 (17%) were rated Brooker grade 1, 16 (5%) grade 2 and 7 (2%) grade 3. One patient had heterotopic ossifications of Brooker grade 4. Two patients underwent excision of heterotopic bone for pain and decreased movement.

Acetabular Component

The median abduction angle of the component was 47° (44°-50°). Inadequate seating of the cup was noted on the initial post-operative radiographs in 103 hips (31%, 1 mm in 56 hips, 2 mm in 41 hips and 3 mm in 4 hips). At the individual last follow-up radiolucencies

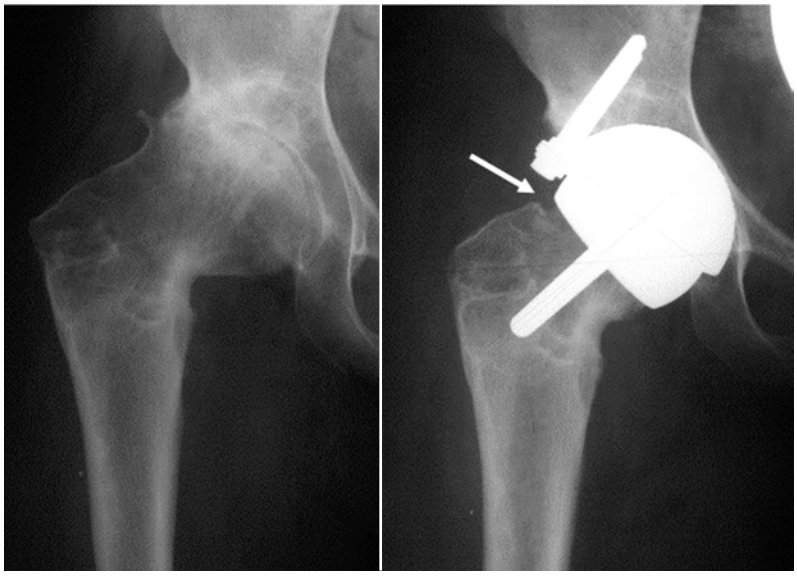

Fig. 2. Pre- and postoperative radiographs showing a notching of the lateral femoral neck.

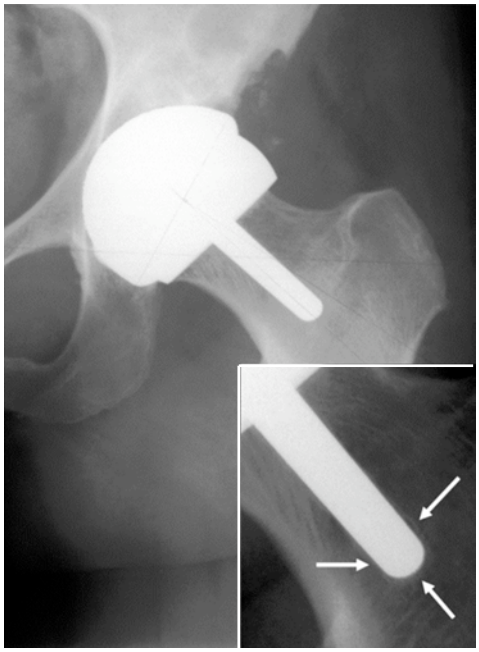

Fig. 3. Hip radiograph of a 58 year old woman, made 47 months after BHR arthroplasty, showing femoral radiolucencies around the tip of the metaphyseal stem.

were observed in 6 hips (2%) in one Charnley zone: two hips had a lucency line of 1 mm in zone I, three hips had radiolucencies up to 2 mm in zone II and two further hips showed a lucency line of 1 mm in zone III.

Femoral Component

Femoral head cysts larger than 1 cm were seen pre-operatively in 168 hips (56%). An overall neutral to slight valgus alignment of the femoral component (median 2.9° valgus, interquartile range 0° – 6°) was noted when compared with the preoperative neck-shaft angle (median 136°, interquartile range 132° – 141°). A notching of the lateral femoral neck was visible in 10 cases (3%) and of the medial femoral neck in one further case on the postoperative a.p. radiographs (Fig. 2). At the last follow-up three femoral components (1 %) showed radiolucency lines in zone II around the tip of the metaphyseal stem (Fig. 3). None of the patients showed radiolucency lines in all Charnley and modified Gruen zones or migration of the components.

Complications

The complications are listed in Table IV.

Intra-operative Complications

In one case the femoral component was implanted in more than 30° varus and revised into a cementless THR with a modular head to avoid neck fracture.

In a patient with an osteoporosis after long-term cortison therapy, the cup was not primarily stable and was revised into a BHR Dysplasia cup the first post-operative day.

In one case we damaged the iliopsoas tendon during anterior capsulotomy. Although suturing was impossible, the patient's outcome (Harris hip score of 100 points) was not influenced.

A fissure of the posterior acetabular wall took place during cup impaction in one female with a CDH and was treated by partial weight bearing over 6 weeks. Twice a retained guide wire had to be removed.

5 patients showed sciatic nerve palsy in the immediate post-operative period. Three palsies with minor symptoms recovered within a few days to 3 weeks. Two patients with major symptoms underwent exploration of the sciatic nerve. Although no obvious cause was found they did not recover.

Post-operative Complications

There were one early and two late deep infections. One hip was revised without exchange of the implants and healed under antibiotic treatment. In two cases the devices had to be temporarily explanted replanted into a THR after recovering under antibiotic therapy.

One hip dislocated on the fourth postoperative day during a collapse. One patient, already revised due to late infection 18 months after implantation, dislocated

Table IV. Absolute and relative frequencies of postoperative complications in 300 hips (263 patients) after total hip arthroplasty.

Complication	absolute and relative (%) frequency
retained guide wire	2 (0.7%; revision)
fracture	
femoral neck fracture	2 (0.7%; one revised into THR)
pertrochanteric fracture	1 (0.3%; plate osteosynthesis)
acetabular wall fissure	1
dislocation	2 (0.7%)
deep infection	3 (1.0%)
early	1 (temporary explantation)
late	2 (one revision, one temporary explantation)
sciatic nerve palsy	5 (1.7%)
minor symptoms, recovered	3
not recovered	2 (0.7%)
femoral component malposition	1 (0.3%; revised into THR)
primary unstable cup	1 (0.3%; revised into BHR Dysplasia cup)
chronic inguinal pain	1 (0.3%; cup revision into higher anteversion)
damage of the iliopsoas tendon	1 (0.3%)

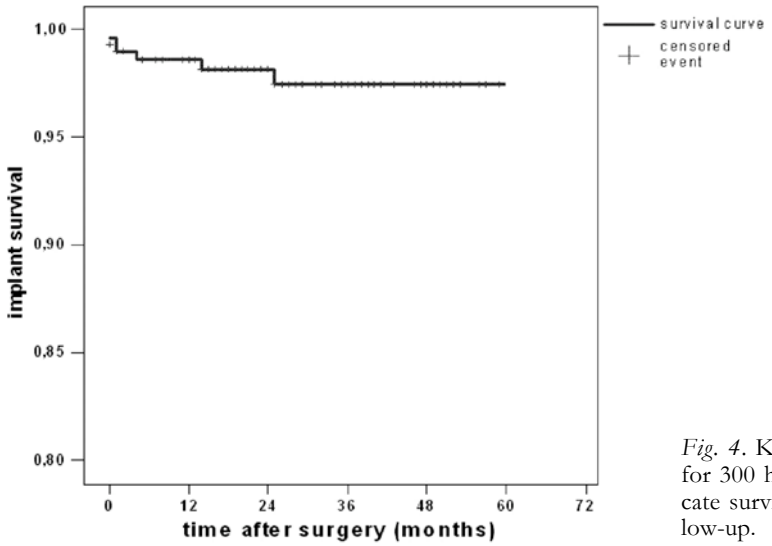

Fig. 4. Kaplan/Meier over-all survival time estimator curve for 300 hips after BHR implantation: point estimates indicate survival rates (%), "+" indicates censored loss to follow-up.

his hip twice, 26 months post-operatively after falling down a staircase. In both cases a closed reduction was performed.

We observed one non-traumatic displaced femoral neck fracture in a 56-year-old female 4 weeks after surgery. A second neck fracture occurred in a 54-year-old woman between 3 months and 1 year post-operatively without major symptoms and was visible at 1 year after surgery. Because the former fracture was radiographically stable and the patient pain free, a revision was not indicated. 3 years post-operatively a Harris hip score of 88 points and no migration of the femoral component were found.

Revisions of the Implant

In 6 patients the device had to be revised (resulting in a failure rate of 2% after a median follow-up of 24 months); 4 hips were converted to total hip replacement (Fig 4). Two deep infections were temporarily explanted and replanted into a THR after recovering under antibiotic therapy (one patient in another hospital). One Patient with a malposition of the femoral component and one patient with a femoral neck fracture were revised on the femoral side into a cementless stem with a modular head. One unstable cup in a patient with osteoporotic bone after long-term cortisone therapy was revised into a BHR Dysplasia cup one day after implantation. One patient had chronic inguinal pain after surgery and an anteversion of the cup. During revision a bursitis between the iliopsoas tendon and the anterior border of the cup was visible and the anteversion of the cup corrected; the symptoms partially disappeared afterwards.

Discussion

The results of total hip arthroplasty have been excellent in older age-groups; however, for young and active patients, the failure rates are unsatisfactorily high. (Callaghan et al. 1997, Duffy et al. 2001, Malchau et al. 2002) In this context, the concept of resurfacing the

hip joint promises attractive features because of its ability to preserve femoral bone and to reduce bony adaptations around the diaphyseal stems. (Kishida et al. 2004, Harty et al. 2005)

Historically, resurfacing of the hip has failed good reputation and its re-introduction met some understandable skepticism. However, pilot studies in the past decade have demonstrated good short-term results using hybrid fixation with a cemented head and a cementless socket. (McMinn et al. 1996, Schmalzried et al. 1996, Wagner and Wagner 1996) The latter findings have motivated re-introduction of the concept into clinical practice at our Department despite the department's negative experiences with the Wagner resurfacing in the eighties. (Paul 1998)

The evolution of the modern metal-on-metal hip resurfacing arthroplasty has been bedeviled by media involvement, so that patient pressure, rather than orthopaedic study, has dominated hip resurfacing arthroplasty for a significant period of time, and to some extent, this situation still prevails. (Villar 2004) However, results are slowly appearing. Recently published single-surgeon series showed excellent short to mid-term results of the method. (De Smet et al. 2002, Pollard et al. 2003, Amstutz et al. 2004, Beaule et al. 2004, Daniel et al. 2004, Back et al. 2005, Treacy et al. 2005) But, there are unpublished reports of higher failure rates especially during the first procedure applications, illustrating that hip resurfacing is a technically demanding procedure. The National Institute for Clinical Excellence (NICE) in the United Kingdom has regarded hip resurfacing as a separate technology to total hip replacement. (N.I.C.E. 2002) In 2002 it has reported on resurfacing, but has recommended special training.

We have presented a consecutive multi-surgeon case series of the first 300 hips which underwent BHR arthroplasty. We found a short-term over-all survivorship of 98% in this younger patient population with a high number of DDH cases. Patients after acetabular graphting using the dysplasia cup of the system showed in a previous investigation equal functional outcome compared to idiopathic arthritis patients after the 6th postoperative month. (Knecht et al. 2004)

Component revisions had to be performed due to infection (0.7%), femoral neck fracture (0.3%) and component malposition/primary instability (1%). With respect to the learning process of the surgeons concerning the rather new BHR procedures these results are very satisfactory with complication rates similar to total hip replacement arthroplasty and comparable with those of recently published single-surgeon series. But, at this early stage, our series does not allow a statement about the long-term results and factors possibly affecting clinical outcome and / or implant survival.

The most significant early complication of the method is a displaced femoral neck fracture. We observed one such case and believe that poor bone quality of this 56-year-old woman (Singh grade 4) was the underlying cause, because a notching of the neck was not visible. On the other hand, notching occurred somewhat frequently in our case series (4% of all implantations) without leading to femoral neck fracture. We believe that treatment of these patients with partial weight-bearing may have avoided the theoretical increase in the fracture risk during the early post-operative period.

It should be critically emphasized that the conclusions mentioned above were drawn from retrospective data; the underlying study design suffers from a control cohort of comparably hip arthritis patients, who underwent conventional total hip replacement and subsequent follow-up. In addition the lacking data completeness must be kept in mind: Not all patients were available for each assessment time during the follow-up period of 5 years. A few patients were only assessed at some of the follow-up times; others had only very small follow-up durations due to their date of surgery. The longest follow-up periods were available for patients, who underwent BHR in 1998 and 1999. On the other hand, these patients might have undergone a learning process of the surgeons concerning the rather new BHR procedures (i.e. the duration of follow up might be associated by a latent risk factor and thereby confounded).

Conclusions

We have presented a multi-surgeon case series of the first 300 hips which underwent BHR arthroplasty. The results are very satisfactory and comparable with those of recently published single-surgeon series. We consider that the early outcome of the BHR has been very satisfactory and has allowed our patients an excellent return of function. There is no doubt, however, that hybrid metal-on-metal hip resurfacing has a part to play in modern orthopaedic surgery. But whether the survival rate equals the excellent results of total hip replants in the elderly still remains to be awaited.

Continued close follow-up is needed to better define the results and indications for this procedure and to overcome the lack of evidence linking metal-on-metal total hip arthroplasty with possible local and systemic long-term effects. (Willert 2000, Campbell 2001, Skipor et al. 2002, Clarke et al. 2003, Willert et al. 2005, Witzleb et al. 2006, Witzleb et al. 2007)

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