THE JOURNAL OF BONE & JOINT SURGERY (BR)

Early results of primary Birmingham hip resurfacings

AN INDEPENDENT PROSPECTIVE STUDY OF THE FIRST 230 HIPS

D. L. Back,
R. Dalziel,
D. Young,
A. Shimmin

From the Melbourne Orthopaedic Group, Melbourne, Australia

We describe the experience with the first consecutive 230 Birmingham hip resurfacings at our centre. At a mean follow-up of three years (25 to 52 months) survivorship was 99.14% with revision in one patient for a loose acetabular component and one death from unrelated causes. One patient developed a fracture of the femoral neck at six weeks which united unremarkably after a period of non-weight-bearing. The Harris hip score improved from a mean of 62.54 (8 to 92) to 97.74 (61 to 100). The mean flexion improved from 91.52° (25 to 140) to 110.41° (80 to 145).

Most patients (97%) considered the outcome to be good or excellent. Our preliminary experience with this implant is encouraging and the results are superior to the earlier generation of resurfacings for the same length of follow-up.

During the past decade, there has been a resurgence of interest in hip resurfacing as a mode of treatment for the younger, more active patient with hip disease.

Previous hip resurfacing implants have used cement and metal-on-polyethylene bearings.[1-3] This combination has produced poor results because of the production of polyethylene wear debris and subsequent osteolysis.[4,5] By changing to a metal-on-metal bearing of cobalt-chrome alloy, the issue of polyethylene wear is exchanged for that of metallic ionic debris, whose systemic effects have yet to be defined.[6] This type of bearing has been used since the 1960s and, although early manufacturing quality was an issue it has proved reliable.[7,8] The concept of a metal-on-metal bearing for resurfacing the hip, using an uncemented acetabular component and a cemented femoral component gives reliable results with fewer complications.[9,10]

This study provides an independent, prospective, clinical and radiological assessment of the current Birmingham hip resurfacing (BHR; Midland Medical Technologies, Birmingham, UK) arthroplasty. Our patients remain under clinical and radiological review and longer term results will be available in due course.

Patients and Methods

Between April 1999 and June 2001, we performed 230 consecutive primary BHRs. All patients were available for follow-up.

This group represents the first BHRs performed at our institution. The operations were undertaken by three surgeons (AS, DY, RD). Our initial criteria for consideration for a BHR were the same as for a total hip replacement (THR); pain, limp and limitation of activities of daily living. Patients were considered for a BHR rather than a THR if they were active men under the age of 75 years and active women under the age of 60 years. Outside these age groups patients were considered for BHR on an individual basis.

Bone density scans were performed on women who had radiographic evidence of osteopenia, as classified by the Singh index,[11] and women who were older than 60 years of age but who were still considered suitable for a BHR. If the scan showed evidence of osteopenia or osteoporosis, as classified by the World Health Organisation (osteopenia, T Score - 1 to -2.5 and osteoporosis, T score < -2.5) they were advised to undergo a conventional THR. All patients undergoing a BHR were fully informed by the consenting surgeon (AS, DY, RD) of the options available, watched a video presentation and completed a questionnaire. All were made aware of the lack of long-term results when compared with a conventional THR. Other contraindications to performing a BHR, as well as osteopenia and osteoporosis, included evidence of renal impairment as cobalt and chromium are excreted via the kidneys and there are few data on the long-term effects of elevated ion levels. These patients

■ D. L. Back, BSc, FRCS Ed(Tr & Orth), Specialist Registrar
■ R. Dalziel, MBBS, FAOrthA, FRACS, Consultant Orthopaedic Surgeon
■ D. Young, MBBS, FAOrthA, FRACS, Consultant Orthopaedic Surgeon
■ A. Shimmin, MBBS, FAOrthA, FRACS, Dip Anat, Consultant Orthopaedic Surgeon
Melbourne Orthopaedic Group, 33 The Avenue, Windsor 3181, Melbourne, Australia.

Correspondence should be sent to Mr A. Shimmin; e-mail: ashimmin@optusnet.com.au

©2005 British Editorial Society of Bone and Joint Surgery
doi:10.1302/0301-620X.87B3.15556 $2.00

J Bone Joint Surg [Br] 2005;87-B:324-9.
Received 14 April 2004; Accepted after revision 14 October 2004

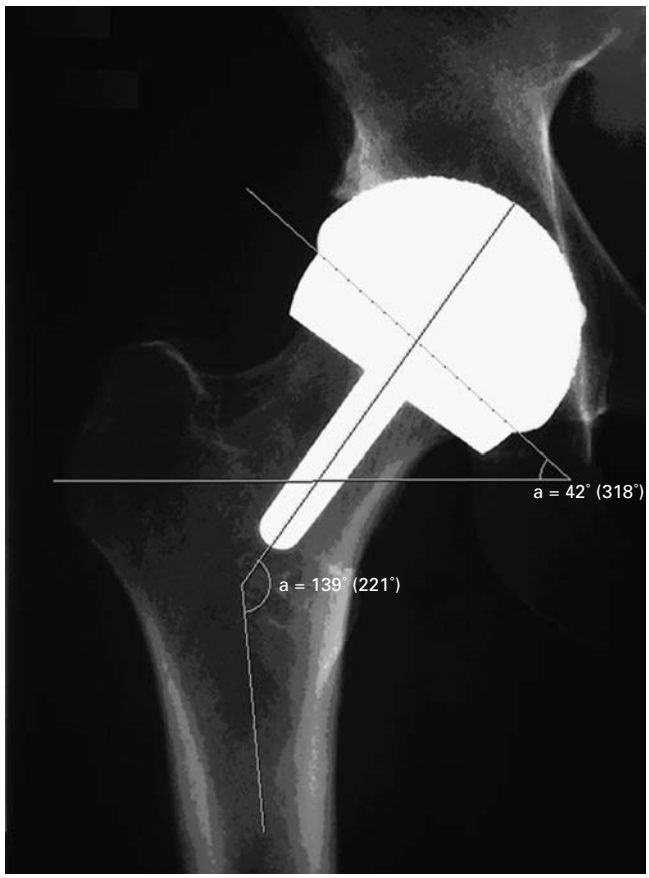

Fig. 1

Post-operative measurements of the hip resurfacing prosthesis.

were offered a ceramic-on-ceramic THR. Thus, all patients with an elevated serum urea and creatinine level were offered a THR, as were patients with known metal sensitivity and those on long-term steroid medication.

Relative contraindications were identified on an individual basis. Previous pelvic and proximal femoral surgery for developmental dysplasia of the hip is often associated with abnormal proximal femoral anatomy and poor femoral and acetabular bone stock. Patients with this history were assessed both radiographically and intra-operatively as to their suitability for hip resurfacing. It is more difficult under these circumstances to obtain a correct version of the components.

A leg length discrepancy of > 3 cm was also a relative contraindication and patients were advised that this could not be corrected, should they wish to proceed with resurfacing. Intra-operatively, if there were large cysts which compromised the femoral bone stock, two options were considered, either bone grafting or conversion to a THR.

All patients were assessed pre-operatively using the Harris hip score,[12] short form-12 score,[13] and the Charnley grades.[14] Post-operatively, an Oxford hip score was also obtained.[15]

Data were collected and statistical analysis undertaken using the Orthowave database, Statware (Orthowave, Epinet, CRDa, Bruay, France). The most recent clinical and radiological review was undertaken by one of the authors (DLB). A survival analysis was performed using a life table.[16]

Radiographic analysis. Anteroposterior (AP) and lateral radiographs were taken pre- and post-operatively, at six months and annually thereafter. All radiographs had a standardised magnification of 115%. Digital radiographic analysis was performed using the OSIRIS 4 system (University of Geneva, Geneva, Switzerland).

Radiolucent lines were recorded around the acetabular component in the zones described by DeLee and Charnley[17] and around the femoral component in the zones described by Amstutz et al.[18] The following measurements were made to determine the implant position on each radiograph (Fig. 1):[19] the pre-operative femoral neck-shaft angle (A); the angle between the stem and the femoral shaft (B); varus or valgus positioning was determined by subtracting B from A (AB). The position of the implant was considered to be valgus if angle B was greater than angle A by > 5°; it was considered to be varus if angle B was less than angle A by > 5°.

The abduction angle of the acetabular component (C) was recorded and the position of the stem relative to the femoral neck was assessed on the lateral radiograph. Heterotopic ossification was classified according to Brooker et al.[20]

Operative technique. All procedures were performed under combined general and spinal/epidural anaesthesia, in a Charnley enclosure, with laminar flow and exhaust suits. A posterior approach was used with an extended incision and release of the tendon of gluteus maximus. An anterior capsulotomy was undertaken and the femoral head displaced anteriorly and superiorly for acetabular exposure.

The acetabulum was prepared using acetabular reamers for a 1 mm press fit and the component positioned in 45° of abduction and anatomical anteversion. The acetabular component is made of cobalt-chrome and has a hydroxyapatite porous coating. Cup size ranges from 44 to 66 mm and each head will articulate with sizes which are 6 and 8 mm larger than the cup. If additional stability is required the dysplasia cup can be used which allows the placement of two rim screws. Only one dysplasia cup was used in this series.

The femur was prepared by successive reaming and shaping of the femoral head. The prosthesis was inserted with Simplex cement (Stryker Howmedica Osteonics, Mahwah, New Jersey), with no cement being placed around the metaphyseal stem (Stryker Howmedica Osteonics). All surgeons planned pre-operatively for a valgus or neutral alignment of the femoral component. A cannula was inserted into the proximal femur to reduce intraosseous pressure during insertion of the femoral component.

Antibiotic prophylaxis consisted of 1 g of intravenous Kefilin (cepholothin), on induction of anaesthesia and three

Table I. Age distribution of the patients at the time of resurfacing

Age (yrs)	Number
15 to 20	3
21 to 25	2
26 to 30	4
31 to 35	5
36 to 40	19
41 to 45	19
46 to 50	28
51 to 55	37
56 to 60	56
61 to 65	36
66 to 70	20
71 to 75	0
76 to 80	0
81 to 85	1

Table II. Pre-operative diagnosis

Aetiology	Number
Osteoarthritis	203
Avascular necrosis	12
Rheumatoid arthritis	3
Neurometabolic	2
Other	10

Table III. Pre-operative and latest Harris hip scores according to Charnley category[14]

Charnley category	Number of arthroplasties	Pain	Movement	Function	Total (range)
A					
Pre-operative	162	21.2	7.9	34.8	63.9 (8 to 93)
Latest	162	43.3	8.9	45.5	97.7 (60 to 100)
B					
Pre-operative	53	16.3	7.6	32.3	56.2 (18 to 82)
Latest	52	43.9	8.8	46.7	99.4 (90 to 100)
C					
Pre-operative	15	20.7	8.8	35.3	64.8 (30 to 98)
Latest	14	36.7	8.3	40.5	85.5 (30 to 100)

Table IV. Pre-operative and latest mean SF-12 scores

Charnley category[14]	SF-12 Physical	SF-12 Mental
A		
Pre-operative	31.1	58.6
Latest	54.1	56.9
B		
Pre-operative	30.3	60.5
Latest	54.1	57.7
C		
Pre-operative	31.5	52.2
Latest	48.2	55.9

subsequent doses at six-hour intervals. Below-knee stockings and per-operative calf stimulators were used for thromboprophylaxis. Additional prophylaxis using heparin, warfarin or aspirin depended on the preference of the individual surgeons. There was no routine prophylaxis for heterotopic ossification, although one patient with an associated acetabular fracture received 25 mg of indometacin twice a day for five days.

Post-operative rehabilitation. This varied between surgeons. One surgeon (DY) mobilised all patients partial weight-bearing with two crutches for two weeks, then one crutch for a further two weeks. The other two (AS, RD) mobilised all patients partial weight-bearing for four to six weeks, subsequently progressing to full weight-bearing over the next six weeks.

Results

Of the 230 hips included in this study, 150 were in men and 80 in women. There were 116 right and 114 left hips. Bilateral procedures were undergone by 17 patients with both hips being entered in the study; seven underwent bilateral, consecutive procedures and ten bilateral, staged procedures. A further 18 patients underwent bilateral staged procedures but with only one hip being included in the study. Fourteen patients received a BHR having already received an earlier contralateral THR.

The mean age of the patients at the time of operation was 52.1 years (18 to 82). The age distribution is shown in Table I. The mean height was 172.18 cm (SD 9.947; mean weight 80.62 kg (SD 15.616) and body mass index 27.02 (SD 4.225). One patient died from unrelated causes and one had undergone revision to a THR because of a loose acetabular component.

The mean follow-up for the remaining patients was 3.0 years (2.0 to 4.4). All surviving patients (228 hips) returned questionnaires and 204 hips remain available for clinical and radiological review. The other 24 hips had all been reviewed at a minimum of two years after surgery.

The pre-operative diagnoses are shown in Table II. In patients under the age of 50 years, previously undiagnosed acetabular dysplasia was more common in females (18) than in men (8).[21]

The outcomes as assessed by the Charnley grade and Harris hip scores are summarised in Table III and SF-12 scores in Table IV. Charnley grade C patients had a significantly lower Harris hip score and function score ($p < 0.001$) than Charnley grade A and B patients. The latest mean Oxford hip score was 13.5 (12 to 28). Lower scores were again seen in the Charnley grade C patients. The range of movement improved in all patients; the mean flexion improved from 91.52° (25 to 130) to 110.41° (80 to 130). The mean length of stay was 7.25 days (3 to 14) and the mean total blood loss was 561.65 ml (230 to 1300).

Complications. These have been divided into medical and operative complications in Tables V and VI. Persistent, significant hypotension was seen early in the series and was

Table V. Post-operative medical complications

Complication	Number
Hypotension	14
Urinary tract infection	9
Deep vein thrombosis	11
Pulmonary embolus	2
Pressure sores	4
Sinus tachycardia	5

Table VI. Operative complications

Complication	Number
Notched neck	5
Superficial wound infection	11
Fracture (healed)	1
Acetabular introducer wire breakage	4
Retained guide wires	2
Broken drill bit	1
Component mismatch	1
Sciatic nerve palsy	2
Common peroneal nerve palsy	1
Femoral nerve palsy	2
Profunda femoris artery pseudaneurysm	1
Femoral artery damage: anterior incision	1
Rectus femoris intramuscular haematoma	1

associated with bilateral consecutive procedures. There have been 11 superficial wound infections (4.8%). The most common bacteria cultured was *Staphylococcus aureus* (eight cases). All resolved with antibiotics. There have been no deep infections. The rate of technical complications is similar to that in other published series.[9,10,19] The two retained guide wires have been removed and the component mismatch corrected. The nerve palsies presented in the immediate post-operative period. Two patients underwent exploration of the sciatic nerve and no obvious cause was found. The symptoms of nerve palsy improved but there are minor paraesthesiae and persistent mild muscle weakness in four of the five patients.

There were two vascular complications. The profunda femoris artery pseudaneurysm required repair eight days post-operatively. There have been no further complications and this patient's most recent Harris hip score was 100. The femoral artery damage was noted intra-operatively and believed to be caused by a retractor. The patient was placed supine, an anterior incision made and repair undertaken, without any further sequelae.

Revision. One 42-year-old man, Charnley grade C, had undergone revision for a loose acetabular component. He had previously undergone contralateral THR. The early post-operative course was unremarkable but at two months he had developed further pain. All inflammatory markers were normal and a diagnosis of a psoas tendinopathy was made. He received an injection and underwent open exploration, without symptomatic relief. A second opinion was sought and a further exploration undertaken with no effect; 18 months after the initial operation a revision procedure was performed by a second independent senior surgeon. At operation, the acetabular component was found to be loose and the BHR was revised to a THR. Two years later there remained no significant symptoms.

Clickers and squeakers. Many patients describe 'clicking' and 'squeaking' after resurfacing arthroplasty; associated functional deficits are, however, very rare.

There were 53 clickers (22.9%). These patients were aware of a clicking feeling in their groin without functional deficit or pain. There appeared to be an association with oversized components relative to the pre-operative radiographs. However, the sample size was still too small for statistical analysis. We believe this may be due to the tendon of psoas impinging on the anterior surface of the acetabular component.

There were nine squeakers (3.9%). These were usually isolated episodes which occurred within six months of the operation. These patients described an episode of squeaking when the hip was at the limit of flexion or when picking up a heavy load. The episode lasted between 20 and 30 minutes and only recurred in one patient who has described three work-related episodes, all under the same circumstances. There did not appear to be any adverse effect on the prosthesis. We believe that this phenomenon may be due to disruption of the fluid film between the two bearing surfaces.

Radiological results. There were 210 complete sets of radiographs. The incomplete sets all had a radiograph taken less than eight months after the operation and these were included where appropriate.

Acetabular component. There were no radiolucent lines around the acetabular components. Inadequate seating was noted on the initial post-operative radiographs in eight cases. At two years there was bony ingrowth in all cases. The mean abduction angle of the component was 45.8° (37 to 65).

Femoral component. There were no radiolucent lines noted in the zones of Amstutz et al.[18] An overall valgus alignment of the femoral component was noted when compared with the pre-operative neck-shaft angle (mean 2.9°). Poor seating of the component was noted in seven cases. One patient had an erosion on the inferior aspect of the femoral neck because of local impingement on the acetabular component. On the lateral radiographs there was great variation in the position of the stem; 115 components had an anterior orientation and none were placed posteriorly.

There were no fractures of the femoral neck requiring revision of the prosthesis. Six patients had evidence of notching on the immediate post-operative radiograph. One developed a fracture of the femoral neck six weeks after operation (Fig. 2). He was treated with a period of non-weight-bearing for six weeks and the fracture healed, with marked neck narrowing (Fig. 3). The prosthesis is still *in situ* three years later. The remaining patients with notching

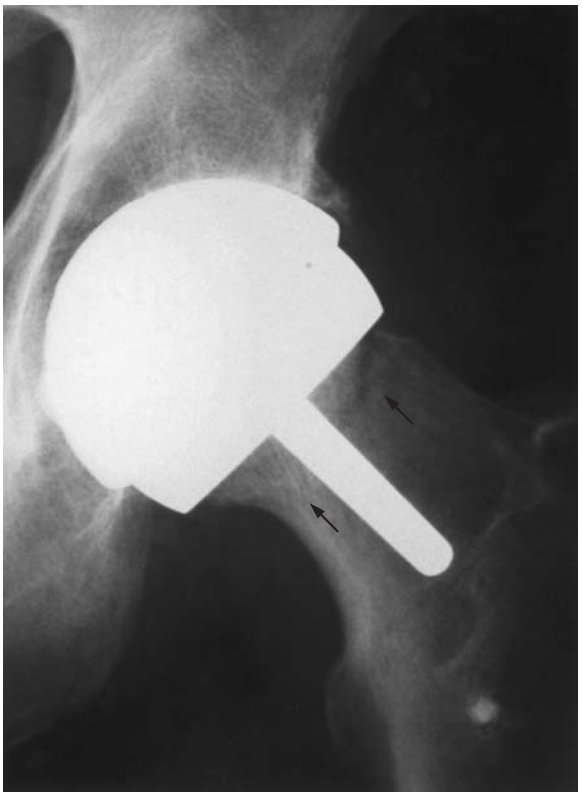

Fig. 2

Fracture of the femoral neck at 15 weeks post-operatively.

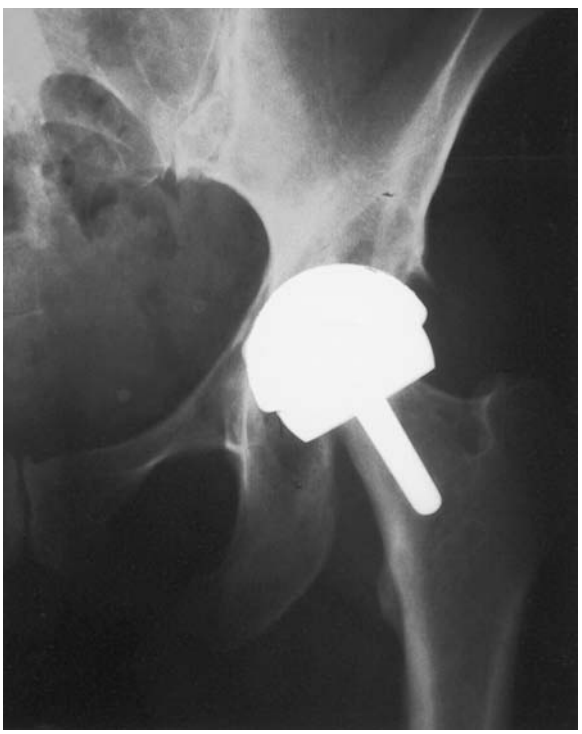

Fig. 3

Healing of the fracture with the marked narrowing of the neck at three years post-operatively.

were mobilised partial weight-bearing with no further progression. Four patients presented with pain within one year of resurfacing. Radiographs showed a subtle cortical bony reaction on the superior aspect of the femoral neck. All were treated with a period of non-weight-bearing and the symptoms settled without radiographic evidence of progression. We believe these represent a form of stress fracture of the femoral neck.

Heterotopic ossification was present in 59.56% of hips. There were no cases of Brooker grade 4. The majority of the cases, 88 (38.26%) were grade 1 and 31 (13.48%) were grade 2 and 18 (7.83%) of hips were grade 3. Three patients underwent excision of heterotopic bone at a mean of one year (10 to 14 months) after surgery for pain and decreased movement. Their outcome scores at the latest follow-up (Harris hip scores 96, 98 and 90, respectively) were the same as those who had not undergone further procedures. Flexion was maintained at a mean of 110° (100 to 120). At the latest follow-up there was no difference between those patients with heterotopic bone and those without. The cumulative survival rate was 99.14% at three years.

Discussion

Previous generations of hip resurfacings have produced variable results. Early results from Furaya et al,[1] Amstutz et al,[2] Freeman et al,[3] and Wagner[4] all showed impending failure by two years' follow-up.

Our series shows improved survivorship (99.14%).[1-4] The problems of polyethylene-induced osteolysis would appear to have been overcome by changing to a metal-on-metal bearing. Our series would appear to support the use of a metal-on-metal hip resurfacing, as we have seen no evidence of osteolysis around either component. There was one loose acetabular component requiring revision, but there is currently no radiographic evidence of loosening of the remaining acetabular components at a mean of three years.

At this early stage, the position of the femoral component does not appear to affect the outcome. However, Freeman[22] clearly demonstrated that the optimum placement was in valgus, to allow loading on the medial trabeculae. It remains to be seen whether this is correct for the long-term survivorship of the BHR and we will continue to compare the results of those components placed in varus with those in valgus.

The most significant early complication is a displaced femoral neck fracture. We have not experienced this complication, although notching occurred in our series. However, we believe that by treating these patients with partial weight-bearing, we have avoided the theoretical increase in the risk of fracture in the early post-operative period.[23]

We have presented an independent multi-surgeon series of the first 230 hips performed in our practice. The results are comparable with recently published single-surgeon series and illustrate our experience in bringing a new pro-

cedure into our practice.[10,19] We consider that the early outcome of the BHR has been very satisfactory and has allowed our patients an excellent return of function. This cohort will be followed further in order to identify the place of resurfacing arthroplasty in the management of hip disease.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

1. **Furuya K, Tsuchiya M, Kawachi S.** Socket cup arthroplasty. *Clin Orthop* 1978;134: 41-4.
2. **Amstutz HC, Dorey FJ, O'Carroll PF.** THARIES resurfacing arthroplasty: evolution and long-term results. *Clin Orthop* 1986;213:92-114.
3. **Freeman MAR, Cameron HU, Brown GC.** Cemented double cup arthroplasty of the hip: a 5 year experience with the ICLH prosthesis. *Clin Orthop* 1978;134:45-52.
4. **Wagner H.** Surface replacement of arthroplasty of the hip. *Clin Orthop* 1978;134: 102-30.
5. **Howie DW, Campbell D, McGee M, Cornish BL.** Wagner resurfacing hip arthroplasty: the results of one hundred consecutive arthroplasties after 8 to 10 years. *J Bone Joint Surg [Am]* 1990;72-A:708-14.
6. **Jacobs JJ, Skipor AK, Doorn PF, et al.** Cobalt and chromium concentrations in patients with metal on metal total hip replacements. *Clin Orthop* 1996;329(Suppl): 256-63.
7. **August AC, Aldam CH, Pynsent PB.** The McKee-Farrar hip arthroplasty: a long-term study. *J Bone Joint Surg [Br]* 1986;68-B:520-7.
8. **Amstutz HC, Grigoris P.** Metal on metal bearings in hip arthroplasty. *Clin Orthop* 1996;329(Suppl):11-34.
9. **McMinn D, Treacy R, Lin K, Pynsent P.** Metal on metal surface replacement of the hip: experience with the McMinn prosthesis. *Clin Orthop* 1996;329(Suppl):89-98.
10. **Daniel J, Pynsent PB, McMinn DJW.** 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:177-84.
11. **Krischak GD, Augat P, Wachter NJ, Kinzl L, Claes LE.** Predictive values of bone mineral density and Singh index for the in vitro mechanical properties of cancellous bone in the femoral head. *Clin Biomech* 1999;14:346-51.
12. **Harris WH.** Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty: an end-result study using a new method of result evaluation. *J Bone Joint Surg [Am]* 1969;51-A:737-55.
13. **Dawson J, Fitzpatrick R, Murray D, Carr A.** Comparison of measures to assess outcomes in total hip replacements. *Qual Health Care* 1996;5:81-8.
14. **Charnley J.** The long-term results of low-friction arthroplasty of the hip performed as a primary intervention. *J Bone Joint Surg [Br]* 1972;54-B:61-76.
15. **Dawson J, Fitzpatrick R, Carr A, Murray D.** Questionnaire on the perceptions of patients about total hip replacement. *J Bone Joint Surg [Br]* 1996;78-B:185-90.
16. **Murray DW, Carr AJ, Bulstrode C.** Survival analysis of joint replacements. *J Bone Joint Surg [Br]* 1993;75-B:697-704.
17. **DeLee JG, Charnley J.** Radiological demarcation of cemented sockets in total hip replacement. *Clin Orthop* 1976;121:20-32.
18. **Amstutz HC, Beaule PE, Dorey FJ, et al.** Metal-on-metal hybrid surface arthroplasty: two to six-year follow-up study. *J Bone Joint Surg [Am]* 2004;86-A:28-39.
19. **De Smet KA, Pattyn C, Verdonk R.** Early results of primary Birmingham hip resurfacing using a hybrid metal-on-metal couple. *Hip* 2002;12:158-62.
20. **Brooker AF, Bowerman J, Robinson RA, Riley LH Jr.** Ectopic ossification following total hip replacement: incidence and a method of classification. *J Bone Joint Surg [Am]* 1973;55-A:1629-32.
21. **Birrell F, Silman A, Croft P, et al.** Syndrome of symptomatic adult acetabular dysplasia (SAAD syndrome). *Ann Rheum Dis* 2003;62:356-8.
22. **Freeman MAR.** Some anatomical and mechanical considerations relevant to the surface replacement of the femoral head. *Clin Orthop* 1978;134:19-24.
23. **Cumming D, Fordyce MJ.** Non-operative management of a peri-prosthetic subcapital fracture after metal-on-metal Birmingham hip resurfacing. *J Bone Joint Surg [Br]* 2003;85-B:1055-6.