Resurfacing arthroplasty of the hip for avascular necrosis of the femoral head

A MINIMUM FOLLOW-UP OF FOUR YEARS

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We performed 96 Birmingham resurfacing arthroplasties of the hip in 71 consecutive patients with avascular necrosis of the femoral head. A modified neck-capsule-preserving approach was used which is described in detail. The University of California, Los Angeles outcome score, the radiological parameters and survival rates were assessed. The mean follow-up was for 5.4 years (4.0 to 8.1). All the patients remained active with a mean University of California, Los Angeles activity score of 6.86 (6 to 9). Three hips failed, giving a cumulative survival rate of 95.4%. With failure of the femoral component as the endpoint, the cumulative survival rate was 98.0%. We also describe the combined abduction-valgus angle of the bearing couple, which is the sum of the inclination angle of the acetabular component and the stem-shaft angle, as an index of the optimum positioning of the components in the coronal plane.

Using a modified surgical technique, it is possible to preserve the femoral head in avascular necrosis by performing hip resurfacing in patients with good results.

The surgical management of avascular necrosis of the femoral head is a challenging task. Procedures reported in the literature range from core decompression,¹ vascularised fibular grafting,² transtrochanteric osteotomy,³ hemiresurfacing,⁴ total hip replacement (THR)⁵ and resurfacing arthroplasty of the hip.⁶ Of these, hemiresurfacing has been reported to give poor results.⁴ The outcome of THR has been conflicting with both favourable^{5,7,8} and unfavourable reports.^{9,10} Avascular necrosis of the femoral head predominantly affects younger patients compared to osteoarthritis.¹ However, success rates of 93% to 96%^{6,11} following THR for avascular necrosis of the femoral head have been reported. We now describe our experience with resurfacing arthroplasty of the hip and present our results with a minimum follow-up of four years.

Patients and Methods

We offered resurfacing arthroplasty to patients who attended our clinic with late-stage avascular necrosis of the femoral head and advanced secondary degenerative changes. All patients in the early pre-collapse category were managed conservatively with non-steroidal anti-inflammatory agents and alendronate, and by modification of activity and core decompression if appropriate. The use of alendronate in these patients has been

shown to give good short-term results.¹² Resurfacing arthroplasty was not offered at this stage. If pain necessitated an arthroplasty a THR was carried out.

Between May 2000 and 2005, 85 consecutive patients (111 hips) underwent surgery for late-stage avascular necrosis of the femoral head. Of these 73 (99 hips) had a resurfacing arthroplasty. The approval of the local ethical committee was obtained and all the data on these patients were collected. Two patients (three hips) were lost to follow-up which left 71 patients (96 hips) for evaluation; 36 patients (36 hips) were unilaterally afflicted and 25 patients (50 hips) had involvement on both sides. In an additional ten patients with involvement of both sides, one hip in each patient was resurfaced beyond the time-frame of the study, and thereby did not satisfy the minimum of four years of follow-up for inclusion in the study. In order to minimise the influence on outcome analysis, two additional groups were derived from the original study group. One group excluded the ten patients bilaterally afflicted with only one hip included for the study and the other excluded the four patients who did not present to the clinic for follow-up. University of California, Los Angeles (UCLA)¹³ scores were obtained for all three groups.

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Fig. 1a

Fig. 1b

Fig. 1c

Photographs showing a) the profile, chamfer and zenith cuts with the dotted white line denoting the halfway mark of the profile cut, b) the contained defect restricted to the chamfered region of the prepared head and c) a defect extending beyond half the profile cut making it unsuitable for placing a resurfacing femoral implant.

Operative technique. In the lateral position and under general anaesthesia the hip was exposed through the neck-capsule-preserving approach, a modification of the extended posterior approach. The tendon of gluteus maximus was released routinely, the ascending branch of the medial circumflex artery was sacrificed and the short external rotators were incised without disturbing the joint capsule. The capsule was then incised close to the acetabulum to preserve the retinacular vessels. At no point was the bony femoral neck exposed. The rest of the procedure was performed as described by McMinn.¹⁴ The Birmingham hip resurfacing prosthesis (Smith and Nephew, Warwick, United Kingdom) was implanted in all the patients. The acetabular component was placed in anatomical version and inclination. Version was achieved by aligning the inferior edge of the component parallel to the transverse acetabular ligament and inclination by placing the component such that the transverse acetabular ligament was exposed in front of it.¹⁵ Whenever feasible, a bridge of bone/osteophyte 3 mm in size was left intentionally beyond the anterior edge of the component to prevent impingement of the psoas tendon.¹⁶ The femoral component was placed in valgus orientation to the native neck-shaft angle. Resurfacing was performed only in the presence of intact bone at the head-neck junction to at least half the height of the profile cut for the implant of the intended size (Fig. 1a). This allowed low-viscosity cement (Surgical Simplex P; Howmedica International, Limerick, Ireland) to be contained in the defect (Fig. 1b). Cysts in the head-neck junction could possibly allow cement to flow out (Fig. 1c) and large central cysts could allow accumulation of cement around the femoral peg. In these circumstances resurfacing was abandoned. Over-resection of the zenith of up to 3 mm was performed in the presence of cysts in order to reduce the volume ratio of the cyst to bone. The cysts were cleared of

soft tissue, loose necrotic bone was aggressively removed and sclerotic bone drilled with a 3.2 mm drill to allow the penetration of the cement. Capsule-to-capsule closure was carried out with No. 2 Ethibond sutures (Ethicon, Livingston, United Kingdom) to complete of the procedure.

All the patients received three doses of 1 g of cefazolin and enoxaparin until discharge and wore TED stockings for four weeks. At discharge, they were prescribed low-dose aspirin as thromboprophylaxis for four weeks. They were mobilised fully weight-bearing on the first post-operative day. When notching was identified on the post-operative radiograph, patients were advised to bear weight partially for six weeks. No restrictions were imposed otherwise except for the use of an abduction pillow when in the lateral position for four weeks after surgery. The patients were reviewed clinically and radiologically at six weeks, six months, one year and every two years thereafter. All the patients completed a self-administered modified UCLA activity score¹³ pre-operatively and at the latest follow-up (Table I). English was not the first language for most of our patients, and therefore the junior author (BDB) was present at all the interviews to help with the questionnaire. Only anteroposterior radiographs were analysed for the purpose of this study¹⁷ because of the difficulty in standardisation of the lateral views.

Radiologic assessment. We evaluated the neck-stem shaft angle, the inclination of the acetabular component¹⁸ and the centre-edge angle of Wiberg¹⁹ on the radiographs (Fig. 2). Since 35 of 71 patients (60 of the 96 hips) had involvement of both sides, comparison between the affected and the opposite sides was irrelevant and the radiological parameters were determined from the same hip pre- and post-operatively.²⁰ Stem-to-neck and component-lateral-cortex ratios were obtained as described by Revell et al.⁶ Radiographs were inspected for periprosthetic radiolucencies, scalloping of the femoral neck, cement around the

Fig. 2

Radiograph showing the stem-shaft angle (A), the centre-edge angle of Wiberg (B), the acetabular inclination (C), the stem-neck ratio (D) and the component-lateral-cortex ratio (E).

Table I. Details of the University of California, Los Angeles (UCLA) activity score

	Pre-operative	Post-operative	p-value*
UCLA (n = 71) [†]	3.20	6.86	1.214E-13
UCLA (n = 61) [‡]	3.21	6.87	6.525E-12
UCLA (n = 67) [¶]	3.19	6.88	5.485E-13

* p-value calculated by the Wilcoxon signed-rank test

[†] there were a total of 71 patients who were administered a UCLA score

[‡] exclusive of the ten patients with bilateral involvement with only the first hip included in the study since the second fell outside the purview of the study

[¶] exclusive of the four patients who were interviewed by telephone

peg and chamfered cancellous bone beneath the femoral component. Lucencies around the femoral peg were scored using the methods of Amstutz, Campbell and Le Duff²¹ and Pollard et al.²² All the procedures were performed by the senior author (VCB) and the radiographs reviewed and interviews conducted by the junior author (BDB). The complications were recorded from the medical review records.

Table II gives details of the 71 patients (96 hips) and Table III the evaluated radiological parameters. In 60 hips (62.5%), the aetiology of the avascular necrosis of the femoral head was idiopathic. It was secondary to steroid intake in 20 hips (20.8%), trauma in 13 hips (13.5%), HIV infection/retroviral therapy in two (2.1%) and to excessive alcohol consumption in one (1.0%).

Statistical analysis. Gnumeric spreadsheet (The Gnumeric Team) software with R-software²³ was used for statistical analysis on a laptop computer running Ubuntu-Linux. (Canonical Group Limited, London, United Kingdom). The p-value for all numerical values (radiological parameters) was calculated by the paired t-test, ordinal numerical values (outcome scores) by the Wilcoxon signed-rank test and,

Table II. Clinical details (mean, range) of the 71 patients (96 hips)

Age in years	39.0 (18.0 to 69.0)
Weight in kg	72.7 (46.0 to 102.0)
Height in metres	169.0 (145.0 to 188.0)
Body mass index	25.5 (17.1 to 42.9)
Male:female ratio	60:11

whenever contingency tables were used, by Fisher's exact test²⁴ (for a contingency table with small sample sizes, Fisher's exact test is preferred over the chi-squared test.²³). Statistical significance was set at $p \leq 0.05$.

Results

The mean follow-up was for 5.4 years (4.0 to 8.1). The mean UCLA scores are shown in Table I. There was a statistically significant improvement. The difference between the mean pre- and post-operative neck-shaft angle was 8.46° which was statistically significant ($< 2.2 \times 10^{-16}$). The mean centre-edge angle of Wiberg decreased by 0.99° ($p = 0.64$) and the mean inclination of the acetabular component increased by 3° ($p = 0.12$), neither of which was statistically significant. A total of 40 (43.5%) hips had thinning of the neck as indicated by a positive difference in the neck ratio. An increase in the mean neck ratio was not statistically significant ($p = 0.1336$). A total of 50 hips (54.4%) had an increase in the component-lateral-cortex ratio. The mean component-lateral-cortex ratio also showed an increase of 0.0084 ($p = 0.24$).

No radiolucencies around the acetabular component, scalloping of the neck, cement around the femoral peg or reamed cancellous bone beneath the femoral component were detected in any of the radiographs. Five acetabular components which did not show complete seating of the acetabular component in the reamed socket in the post-operative radiographs had well-formed trabeculae at the latest radiograph. In 45 hips (48.9%) there were lucencies around the peg. The femoral scores of Amstutz et al²¹ (Table III) and of Pollard et al²² (Table IV) were tabulated against gender and age.

Among other complications, three hips had a superficial and one a deep infection. All the wounds settled except one which required debridement and washout. Exploration showed a sinus tract going down to the acetabular component, but the implant was well-fixed. The patient was managed with antibiotics and remains under active observation. At a follow-up of 4.6 years the patient remains active with a UCLA score of 8 and no signs of loosening. There were four hips with mild weakness of the quadriceps which recovered with no residual deficit two weeks after surgery. An undisplaced fracture of the acetabulum was detected in one hip. After partial weight-bearing for six weeks, the fracture united and the patient remains asymptomatic and active. In two hips the femoral implant had notched the femoral neck. The bone remodelled following protected weight-bearing. There were no dislocations or thrombo-

Table III. Details of the radiological parameters (mean, range) evaluated for 92 hips (67 patients)

	Pre-operative	Post-operative	p-value
Neck-shaft angle (°)	132.9 (115.0 to 152.0)	141.31 (128.0 to 156.0)	$< 2.2 \times 10^{-16}$
Centre-edge angle of Wiberg (°)	36.5 (16.0 to 71.0)	35.93 (7.0 to 60.0)	0.6471
Cup inclination of the acetabular component (°)	43.2 (24.0 to 64.0)	46.2 (22.0 to 76.0)	0.1259
	Immediate post-operative	Latest follow-up	p-value
Implant angle (°)		11.5 (0.0 to 43.0)	
Neck width (mm)	40.3 (25.0 to 50.0)	39.7 (26.0 to 52.0)	0.02934
Stem width (mm)	9.9 (7.0 to 10.0)	9.8 (8.0 to 10.0)	0.3967
Neck ratio	0.3 (0.2 to 0.4)	0.3 (0.2 to 0.4)	0.1336
Length of component (mm)	77.0 (53.0 to 92.0)	77.1 (58.0 to 88.0)	0.854
Tip to lateral cortex (mm)	32.0 (12.0 to 61.0)	32.6 (10.0 to 61.0)	0.3058
Component-lateral-cortex ratio	0.4 (0.2 to 0.8)	0.4 (0.1 to 0.8)	0.242

embolic events. There was one hip with heterotopic ossification (Brooker grade 2²⁵).

Three hips failed. One with migration of the acetabular component and two with varus collapse of the femoral component. The acetabular component in one hip migrated progressively into a vertical orientation. It was revised at 5.7 years after the initial operation to a THR. A patient with avascular necrosis of the femoral head secondary to an united fracture of the femoral neck presented 3.3 years after resurfacing with a gross varus collapse (Fig. 3). At revision the femoral head was completely resorbed leaving only remnants of cement. The second hip with a varus collapse was revised elsewhere at 1.6 years from the initial operation.

The cumulative survival rate was 95.4% (95% confidence interval (CI) 90 to 100) with failure for any reason as the endpoint (Table VI, Fig. 4) which compares well with a survival rate of 93% to 96% reported in the literature.^{6,11} With failure of the femoral component only as the endpoint, the cumulative survival rate was 98.0% (95% CI 95.1 to 100).

Discussion

The improvement in the UCLA score remained statistically significant even after exclusion of either the subset of patients with bilaterally affected hips in whom only one hip was included for the study or the four patients who were interviewed by telephone (Table II). However, the presence of the junior author to bridge the language barrier during completion of the outcome questionnaires may have introduced an observer bias.²⁶

The reconstructed hip had the femoral component in valgus orientation. This is in agreement with the findings in the literature.²⁰ In recent studies a steep angle of the acetabular component ($> 55^\circ$) has been shown to be detrimental with an increased presence of metal ions and probable increased wear.^{27,28} De Haan et al²⁷ described the arc of cover to indicate the cover of the proximal pole of the

femoral component by the lateral edge of the acetabular component.

In the coronal plane the position of the femoral component in the resurfacing can vary significantly in contradistinction to the fixed implant-related stem-shaft angle on the femoral side of a THR. Combined anteversion in the hip implies the sum of the anteversion of the acetabulum and the femur.²⁹ Similarly to combined anteversion²⁹ we propose the combined abduction-valgus angle of the bearing couple for assessing orientation of the component. This can be obtained by adding the abduction (inclination) angle of the acetabular component to the stem-shaft angle, the latter indicating the valgus position of the femoral component. The mean combined abduction-valgus angle of the acetabular component in our series was 186.7° (95% CI 173.4 to 199.9). The skewed upper 95% CI followed the obtuse stem-shaft angles (mean 140.0° ; 95% CI 128.4 to 151.6) in several of our early cases. The pre-operative mean neck-shaft angle was 132.9° (115° to 152°). It has been suggested that valgus placement is best for physiological strain patterns in the proximal femur.³⁰ Varus placement is certainly not desirable, but neutral to valgus placement may be acceptable depending on the inclination of the acetabular component achieved to arrive at an optimum abduction-valgus angle of the acetabular component of 180° (170° to 190°), indicating parallelism of the components (Fig. 5). The data which we present in relation to this angle are proof of the concept rather than valid corroborative evidence. Since we realised the importance of this angle, we have used it in all our successive cases. Thinning of the neck, as described by Treacy, McBryde and Pynsent³¹ was seen in 40 (43.5%) hips and 45 hips (48.9%) demonstrated lucencies around the femoral peg. The scores of Amstutz et al²² and Pollard et al²¹ showed no significant correlation with either gender or age. We agree with Pollard et al²² that these radiological appearances are likely to represent dense sclerotic lines creating an illusion of a lucency in the adjacent bone. Condensation of bone is likely to occur after good fixation of the proximal aspect with an

Fig. 3a

Fig. 3b

Fig. 3c

Fig. 3d

Radiographs of a patient with delayed varus collapse showing the appearance a) one year before the initial operation, b) immediately before the initial operation, c) six months post-operatively and d) three years post-operatively. The screws relate to incompletely removed hardware from the previous surgery.

Table IV. Distribution of the Amstutz²¹ femoral score according to age and gender for 92 hips (67 patients)

Zones	Amstutz score	Gender		Age (yrs)	
		Female	Male	> 55	< 55
None	0	7	40	4	43
1	1, 2 or 3	1	16	0	17
2	4, 5 or 6	1	12	1	12
3 incomplete	7	4	9	0	13
3 complete	8	1	1	0	2
Migration	9	0	0	0	0

uncemented peg distally. It is not surprising that a recent study³² describing cementing of the femoral peg in selected cases has reported no lucencies. Asymmetrical lucencies denoting the wiper effect of a loose femoral component are probably more relevant. The two hips with varus collapse in our series had thinning of the neck and asymmetrical lucencies. This has also been our observation in a separate series involving patients with inflammatory arthropathy (currently unpublished). Thinning of the femoral neck or lucencies around the femoral peg, independently, are common phenomena after resurfacing. However, the appearance of both of these together may signal an impending varus collapse. No hips had lucency around the acetabular component. In

Fig. 4

Kaplan-Meier survival curve with failure for any reason as the endpoint for all 96 patients.

the single case of migration of the acetabular component, a clear demarcation between the implant and the floor of the

Fig. 5

Radiograph showing the abduction valgus angle of the acetabular component (CAVA). A is the stem-shaft angle and B the inclination angle of the acetabular component. The CAVA = angles A+B. The lines X and Y must be parallel (co-planar) in the anteroposterior radiograph to achieve an ideal CAVA angle.

Table V. Distribution of the Pollard²² femoral score according to age and gender for 92 hips (67 patients)

Pollard score	Gender		Age (yrs)	
	Female	Male	> 55	< 55
0	7	40	4	43
1a	1	12	0	13
1b	3	22	1	24
1c	2	3	0	5
2	1	1	0	2
3	0	0	0	0

Table VI. Life table for all the hips

Time (yrs)	Number at risk	Number of failures	Cumulative survival rate	SEM	95% CI*	
					Lower	Upper
For all failures (n = 96)						
1.57	96	1	0.990	0.0104	0.969	1.000
3.37	95	1	0.979	0.0146	0.951	1.000
5.65	39	1	0.954	0.286	0.900	1.000
Worst-case scenario (n = 99)						
1.57	99	1	0.990	0.0100	0.970	1.000
2.15	98	1	0.980	0.0141	0.952	1.000
2.21	78	2	0.960	0.0198	0.922	0.999
3.37	66	1	0.949	0.0220	0.907	0.994
5.65	39	1	0.925	0.0322	0.864	0.990

* CI, confidence interval

acetabulum was visible. Otherwise, all the acetabular components had trabecular bone extending on to the surface suggesting bony integration.

The major weakness of our study is the loss to follow-up of three hips. The cumulative survival rate in the worst-case scenario was 92.5% (95% CI 86.4 to 99.0; Table VI). Radiographs of these three hips which were available at follow-up at one year showed well-fixed implants with no thinning of the neck or lucencies. Appropriate validation of the combined abduction-valgus angle of the acetabular components measurement is necessary. Outcome measures may have been overestimated as explained earlier. Factors relating to a single-centre and single-surgeon study apply as well.

Resurfacing arthroplasty of the hip for avascular necrosis of the femoral head at a mean medium-term follow-up of 5.4 years showed a cumulative survival rate of 95.4%

with failure for any reason as the endpoint. Although there is a question in regard to furthering the vascular insult through a posterior exposure with the neck-capsule-preserving approach, there were only two failures on the femoral side giving a cumulative survival rate of 98.0%. The high outcome score indicated that patients continue to remain active after surgery. Measurements of the combined abduction-valgus angle of the acetabular components are of value for optimal positioning. Lucencies around the femoral peg and thinning of the neck do not appear to be significant. We conclude that by avoiding operating on patients in the early stages of avascular necrosis of the femoral head and by using certain modifications to the standard surgical technique, it is possible to perform resurfacing arthroplasty in these patients and to achieve good results.

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