



## Clinical and radiological outcome following total hip arthroplasty with an uncemented trabecular metal monoblock acetabular cup

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Uncemented acetabular components are associated with a significant incidence of polyethylene wear and secondary osteolysis. The new tantalum/polyethylene composite (Hedrocel) acetabular component is designed to reduce the polyethylene wear and to increase the longevity of the acetabular cups. We report our short-term clinical outcome and patient satisfaction following use of an uncemented tantalum acetabular component in a single centre.

During 1999 to 2002, 113 uncemented tantalum acetabular cups were implanted in 105 patients in our institution. The average age at operation was 56.8 years. All patients were assessed pre- and post-operatively with the Oxford 12 item hip questionnaire and standard radiographs of the pelvis. At a mean follow-up of 32 months (range: 18 to 48), 112 Hedrocel cups were assessed in 104 patients. Subjective patient's satisfaction was also assessed.

At the time of evaluation, one patient had died due to an unrelated cause. Eight patients had bilateral acetabular cups implanted. The mean Oxford hip score improved from 45 preoperatively to 14 post-operatively. Subjectively 99% were very satisfied or satisfied. Only one patient expressed dissatisfaction about the outcome of this surgery. Radiologically, there were no signs of cup loosening or wear.

This study shows that at short-term the new uncemented tantalum/polyethylene composite (Hedrocel) acetabular component can yield a satisfactory clinical and radiological outcome and has a high patient satisfaction. Although the short-term result from our centre is very encouraging, similar results from other centres and longer follow-up are required.

**Keywords:** uncemented hip arthroplasty; tantalum monoblock cup; clinical outcome; radiological outcome.

## INTRODUCTION

Total hip arthroplasty is a well-established procedure for arthritis of the hip. Loosening of the components has been a major cause of failure in the long-term survival of the implants, resulting in revision surgery. To address the reported long-term problems associated with the first generation prostheses inserted with cement and cementing techniques (14-16, 33, 45, 46), extensive research over the last three decades have been focused towards improving the prosthesis design (17, 18), cementing techniques and development of cementless implants to enhance fixation by bony ingrowth (7,

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12, 24-26, 29, 35). Despite improved cementing techniques and changes in design, many investigators have reported the late loosening of the acetabular component to be a major persisting problem associated with cemented total hip arthroplasty (39, 40). This led to the development of acetabular components that were designed to be inserted without cement. To enhance the biological fixation of these implants, most cementless acetabular components have various porous coatings like those manufactured by sintering of cobalt-chrome or titanium beads and the diffusion bonding of titanium fibre wires (28). Pelvic osteolysis seen around the cementless cup design was attributed to the polyethylene wear debris resulting from the micro-motion between the nonarticulating side of the polyethylene liner and the interior of the metallic shell (backside wear). These concerns led to extensive research in the field of component design over the last decade and a non-modular monoblock acetabular cup (TMT - Hedrocel, Zimmer Ltd, Swindon, UK) made from commercially available porous tantalum biomaterial was developed (9). This monoblock acetabular cup has been used both in primary and revision hip arthroplasty since its development in a few centres and has been used in our institution since 1999. To date there are very few reports in the literature regarding the clinical outcome following this monoblock cup in primary and revision total hip arthroplasty (34, 47). The purpose of this report is to present the early clinical and radiological outcome following uncemented trabecular metal monoblock acetabular cups in total hip arthroplasty from a single centre in the United Kingdom. To our knowledge, there are no reports in the literature regarding the clinical outcome following monoblock cup usage from Europe.

#### MATERIALS AND METHODS

Between February 1999 and December 2002, 113 uncemented trabecular metal monoblock acetabular cups were implanted in 105 patients who underwent total hip arthroplasty at our institution by the senior authors (C.J.K. and J.N.D). The primary diagnosis was osteoarthritis in 84 hips (74%), rheumatoid arthritis in three hips (3%) and secondary osteoarthritis in 26 hip

Table I. — Indications for Operations

Primary Osteoarthritis		Secondary Osteoarthritis	
Degenerative arthritis	84	Post Traumatic	10
Rheumatoid arthritis	3	DDH	6
		Avascular Necrosis	6
		Aseptic loosening	1
		Slipped capital femoral epiphysis	1
		Ankylosing spondylitis	1
		Perthes	1

(23%). Table I shows the diagnosis of the 113 hips. The average age of the patients at the time of surgery was 56.8 years (range : 25 to 78). Eight patients had undergone bilateral hip replacements (six patients had undergone staged bilateral hip replacement and two patients had bilateral hip replacement at a single sitting). All the patients were clinically assessed using the Oxford 12 item validated hip questionnaire (19) prior to surgery and a standard antero-posterior and lateral hip radiograph was obtained. The surgery was performed in a clean-air operating theatre with vertical laminar flow. Prophylactic antibiotics, unless contraindicated, were used in all patients (intravenous cefuroxime - 1.5 gm at induction and 750 gm at 8<sup>th</sup> and 16<sup>th</sup> hour postoperatively). Chemical thromboprophylaxis (Tinzaparin 2500 IU until discharge) was used in all the patients, unless contraindicated. The operations were carried out through a standard Hardinge approach. Closed suction drains were used in all patients and were removed between 24 and 48 hours after operation. The patients were mobilised the following day and were discharged home on the 5<sup>th</sup>-7<sup>th</sup> postoperative day depending on their recovery. All patients were followed up at 6 weeks, 3 months, 6 months, and then annually with standard AP and lateral radiographs of the hip. The Oxford 12 item hip questionnaire was used at final follow-up and a standard antero-posterior and lateral hip radiograph was used for analysis. The radiographs were analysed for signs of cup loosening and cup migration as compared to the immediate post-operative implant position using the standard methods (20, 38). Acetabular cup loosening was assessed around the circumference of the socket as categorised into three zones (Type I, II, or III) in the AP film (fig 1) as described by DeLee and Charnley (20). The radiographs were also assessed for vertical migration, horizontal migration and tilting of the socket. Vertical migration was calculated as the distance between the centre of the cup and the teardrop line and the migration along the



**Fig. 1.** — Radiograph of De Lee Charnley zones for acetabular loosening assessment.



**Fig. 2.** — Radiograph shows method used for measuring migration.

horizontal axis was calculated between the centre of the cup and the tear drop line (horizontal line along the teardrop) (fig 2) (38). Patients also completed an expectation and satisfaction questionnaire at the time of final follow-up.

## RESULTS

We reviewed 112 uncemented monoblock acetabular cups in 104 patients at the time of final follow-up. One patient had died due to an unrelated cause. The mean follow-up was 32 months (range : 19 to 54). There were 55 females and 49 males. The left hip was replaced in 48 patients and the right hip in 64. The average weight of the patients was 80 kg (range : 51 to 141). The mean Oxford hip score improved from 45 preoperatively to 14 postoperatively ( $p < 0.05$ ) (the score ranges from 12 to 60, 12 being the best and 60 being the worst outcome). Radiologically, there was no evidence of either loosening or migration of the cup in any patient. Twenty-five hips (22%) showed initial postoperative gaps in zone II, which later filled up and showed full osseointegration during the final follow-up evaluation as shown in fig 3. None of the acetabular cups was revised at the time of last follow-up. Ninety nine percent of patients were either satisfied or very satisfied with the outcome of the operation. Table II shows details regarding the different stems and type and diameter of the heads



**Fig. 3.** — Radiograph shows good osseointegration in all three zones.

Table II. — Types of Prosthesis Used

Uncemented Stem	Cemented Stem	Types of Head (28 mm)
CLS : 86 PFM : 2	Muller Mainstream : 21 Elite : 3 Exeter : 1	Short : 18 Medium : 63 Long : 32

used in this series. Seven patients in our series had mild heterotopic ossification around the hip joint at the time of final follow-up. However, this group of patients did not show any signs of restriction in their hip function.

### Complications

**Wound Infection :** There were no florid superficial wound infections or deep implant infection at the time of final follow-up. Two patients (1.8%) developed deep vein thrombosis during the post-operative period and were treated with warfarin. There were no intra-operative acetabular cracks or fractures requiring further surgery. Two patients (1.8%) developed trochanteric bursitis postoperatively, which resolved with physiotherapy and steroid injection.

Three patients (2.7%) had undergone further surgery for stem related problems like periprosthetic femoral fracture following a fall and recurrent dislocation during the early post-operative period, which required an exchange of the femoral head from short to long neck. The acetabular cups in these three patients did show signs of good osseointegration during surgery.

### DISCUSSION

In the United Kingdom, more than 50,000 total hip replacements are performed annually. Periprosthetic osteolysis and aseptic loosening of the implants are serious problems affecting the long-term outcome of total joint arthroplasty (45, 46). With improved cementing techniques and design changes, the failure rates of the stems improved significantly (39, 40, 43). However, the survival of the cemented acetabular components showed no difference and long term studies have shown the revision rates for acetabular component

to be approximately 10 to 15 percent and rates of loosening of the acetabular component of approximately 20 to 40 percent at fifteen to twenty years post-operatively (36, 40). This led to the development of acetabular components that were designed to be inserted without cement. To enhance the biological fixation of these implants, most cementless acetabular components have various porous coatings like those manufactured by sintering of cobalt-chrome or titanium beads and diffusion bonding of titanium fibre wires (28). Further reports using the uncemented acetabular cups showed good mid-term results with minimal complications (30). Berger *et al* (2) reported a 10-year survival of 96.9% for the femoral component and 98.6% for the acetabular component in their hybrid total hip arthroplasty series using uncemented acetabular porous coated Harris Galante Prostheses (HGP-I) with screws and a precoated femoral component with contemporary cementing technique. However, in another series, Engh *et al* (27) reported a revision rate of 1.5% for cemented stems and 2.2% for uncemented cups at 10 years.

Some authors reported pelvic osteolysis around the cementless cup in their series, especially with cups that have screw holes for secure fixation (37, 44). This phenomenon was attributed to the polyethylene wear debris resulting from the micromotion between the nonarticulating side of the polyethylene liner and the interior of the metallic shell (backside wear) (21, 22). These concerns led to extensive research in the field of component design and structural material, which resulted in the development of a novel porous biomaterial made from commercially available pure tantalum (1, 3). The structural nature of this material enabled manufacturing of implants without the need for a solid metal substrate. Extensive laboratory studies have characterised the physical and mechanical properties (1, 3, 10, 41, 42, 48) of tantalum material and

when compared with conventional porous coatings, tantalum possesses higher volume porosity (75-80%) with more freely communicating pores (550 microns), a higher coefficient of friction against bone and a lower bulk stiffness (10). Recent cell-culture studies and histological analysis have confirmed the osteoblastic response to tantalum, adding further confirmation as a biocompatible material (4-8, 13). Tantalum also has a low stiffness (3.0 Gpa) with reduced stress shielding (subchondral bone-2, cancellous bone-1.7, and cortical bone 15) which makes it a more suitable material. Direct compression moulding of UHMWPE in the tantalum shell for 2 mm avoids the dead space between the polyethylene and the metal, which eliminates the possible complication from backside wear. The hemi ellipsoid outer geometry of the tantalum monoblock cup provides a peripheral rim press fit. The frequency of initial postoperative gaps (22%) seen in our series, in zone II, is similar to the observations made by other authors using uncemented cup designs (23, 31, 32, 44) and is mainly attributable to the outer geometry of the monoblock cup (hemiellipsoid). At final follow-up, these gaps were no longer visible, which suggests good osseointegration between the trabecular metal and the bone as shown by Bobyn *et al* (11) in their canine acetabular model. We did not observe any migration or tilting of the monoblock cup during the initial period or later during follow-up in our series and this phenomenon of cup stability and osseointegration could be explained by the higher coefficient of friction (40% to 70%) than other porous material (10).

Clinically all patients had significant improvement as seen from the changes in their hip scores, and none of the complications noted in our series were directly related to the monoblock cup. Overall, the vast majority of patients, in our series, were very satisfied and reported no difference as compared to their normal hip.

In summary, our series suggests that at short-term, the uncemented porous tantalum monoblock acetabular cup yields a satisfactory clinical and radiological outcome, and has a high patient satisfaction. Although these short-term results for the tantalum cup are highly encouraging, studies from

other centres and with longer follow-ups and implant survival analysis are required to confirm that these results can be sustained.

## REFERENCES

1. **Alberius P.** Bone reactions to tantalum markers. A scanning electron microscopic study. *Acta Anat (Basel)* 1983 ; 115 : 310-318.
2. **Berger RA, Kull LR, Rosenberg AG et al.** Hybrid total hip arthroplasty : 7- to 10-year results. *Clin Orthop* 1996 ; 333 : 134-146.
3. **Black J.** Biological performance of tantalum. *Clin Mater* 1994 ; 16 : 167-173.
4. **Bobyn JD, Engh CA and Glassman AH.** Radiography and histology of a threaded acetabular implant. One case studied at two years. *J Bone Joint Surg* 1988 ; 70-B : 302-304.
5. **Bobyn JD, Engh CA and Glassman AH.** Histologic analysis of a retrieved microporous-coated femoral prosthesis. A seven-year case report. *Clin Orthop* 1987 ; 224 : 303-310.
6. **Bobyn JD, Pilliar RM, Cameron HU et al.** Osteogenic phenomena across endosteal bone-implant spaces with porous surfaced intramedullary implants. *Acta Orthop Scand* 1981 ; 52 : 145-153.
7. **Bobyn JD, Pilliar RM, Cameron HU et al.** The optimum pore size for the fixation of porous-surfaced metal implants by the ingrowth of bone. *Clin Orthop* 1980 ; 150 : 263-270.
8. **Bobyn JD, Pilliar RM, Cameron HU et al.** The effect of porous surface configuration on the tensile strength of fixation of implants by bone ingrowth. *Clin Orthop* 1980 ; 149 : 291-298.
9. **Bobyn JD, Poggie RA, Krygier JJ et al.** Clinical validation of a structural porous tantalum biomaterial for adult reconstruction. *J Bone Joint Surg* 2004 ; 86-A Suppl 2 : 123-129.
10. **Bobyn JD, Stackpool GJ, Hacking SA et al.** Characteristics of bone ingrowth and interface mechanics of a new porous tantalum biomaterial. *J Bone Joint Surg* 1999 ; 81-B : 907-914.
11. **Bobyn JD, Toh KK, Hacking SA et al.** Tissue response to porous tantalum acetabular cups : a canine model. *J Arthroplasty* 1999 ; 14 : 347-354.
12. **Cameron HU, Pilliar RM and Macnab I.** The rate of bone ingrowth into porous metal. *J Biomed Mater Res* 1976 ; 10 : 295-302.
13. **Chan FW, Bobyn JD, Medley JB et al.** Engineering issues and wear performance of metal on metal hip implants. *Clin Orthop* 1996 ; 333 : 96-107.
14. **Charnley J.** *Low Friction Arthroplasty of the Hip. Theory and Practice.* Springer, New York, 1979, pp 25-35.
15. **Charnley J, Cupic Z.** The nine and ten year results of the low-friction arthroplasty of the hip. *Clin Orthop* 1973 ; 95 : 9-25.

16. **Cornell CN, Ranawat CS.** Survivorship analysis of total hip replacements. Results in a series of active patients who were less than fifty-five years old. *J Bone Joint Surg* 1986 ; 68-A : 1430-1434.
17. **Crowninshield RD, Brand RA, Johnston RC et al.** An analysis of femoral component stem design in total hip arthroplasty. *J Bone Joint Surg* 1980 ; 62-A : 68-78.
18. **Crowninshield RD, Brand RA, Johnston RC et al.** The effect of femoral stem cross-sectional geometry on cement stresses in total hip reconstruction. *Clin Orthop* 1980 ; 146 : 71-77.
19. **Dawson J, Fitzpatrick R, Carr A et al.** Questionnaire on the perceptions of patients about total hip replacement. *J Bone Joint Surg* 1996 ; 78-B : 185-190.
20. **DeLee JG, Charnley J.** Radiological demarcation of cemented sockets in total hip replacement. *Clin Orthop* 1976 ; 121 : 20-32.
21. **Devane PA, Horne JG, Martin K et al.** Three-dimensional polyethylene wear of a press-fit titanium prosthesis. Factors influencing generation of polyethylene debris. *J Arthroplasty* 1997 ; 12 : 256-266.
22. **Devane PA, Robinson EJ, Bourne JB et al.** Measurement of polyethylene wear in acetabular components inserted with and without cement. A randomized trial. *J Bone Joint Surg* 1997 ; 79-A : 682-689.
23. **Dorr LD, Wan Z, Cohen J.** Hemispheric titanium porous coated acetabular component without screw fixation. *Clin Orthop* 1998 ; 351 : 158-168.
24. **Engh CA.** Hip arthroplasty with a Moore prosthesis with porous coating. A five-year study. *Clin Orthop* 1983 ; 176 : 52-66.
25. **Engh CA, Bobyn JD.** The influence of stem size and extent of porous coating on femoral bone resorption after primary cementless hip arthroplasty. *Clin Orthop* 1988 ; 231 : 7-28.
26. **Engh CA, Bobyn JD, Glassman AH.** Porous-coated hip replacement. The factors governing bone ingrowth, stress shielding, and clinical results. *J Bone Joint Surg* 1987 ; 69-B : 45-55.
27. **Engh CA, Hooten JP Jr, Zettl-Schaffer KF et al.** Porous-coated total hip replacement. *Clin Orthop* 1994 ; 298 : 89-96.
28. **Friedman RJ, Black J, Galante JO et al.** Current concepts in orthopaedic biomaterials and implant fixation. *Instr Course Lect* 1994 ; 43 : 233-255.
29. **Galante J, Rostoker W, Lueck R et al.** Sintered fiber metal composites as a basis for attachment of implants to bone. *J Bone Joint Surg* 1971 ; 53-A : 101-114.
30. **Heekin RD, Callaghan JJ, Hopkinson WJ et al.** The porous-coated anatomic total hip prosthesis, inserted without cement. Results after five to seven years in a prospective study. *J Bone Joint Surg* 1993 ; 75-A : 77-91.
31. **Incavo SJ, Ames SE, DiFazio FA et al.** Cementless hemispheric acetabular components. A 4- to 8-year follow-up report. *J Arthroplasty* 1996 ; 11 : 298-303.
32. **Incavo SJ, DiFazio FA and Howe JG.** Cementless hemispheric acetabular components. 2-4-year results. *J Arthroplasty* 1993 ; 8 : 573-580.
33. **Kavanagh BF, Dewitz MA, Ilstrup DM et al.** Charnley total hip arthroplasty with cement. Fifteen-year results. *J Bone Joint Surg* 1989 ; 71A : 1496-1503.
34. **Lewis RJ, Unger AS, O'Keefe TJ et al.** Monoblock trabecular metal acetabulum - Two to five year results. *70th Annual Meeting of the American Academy of Orthopaedic Surgeons* 2003 ; New Orleans.
35. **Lord G, Bancel P.** The madreporic cementless total hip arthroplasty. New experimental data and a seven-year clinical follow-up study. *Clin Orthop* 1983 ; 176 : 67-76.
36. **Madey SM, Callaghan JJ, Olejniczak JP et al.** Charnley total hip arthroplasty with use of improved techniques of cementing. The results after a minimum of fifteen years of follow-up. *J Bone Joint Surg* 1997 ; 79-A : 53-64.
37. **Maloney WJ, Peters P, Engh CA et al.** Severe osteolysis of the pelvis in association with acetabular replacement without cement. *J Bone Joint Surg* 1993 ; 75-A : 1627-1635.
38. **Massin P, Schmidt L, Engh CA.** Evaluation of cementless acetabular component migration. An experimental study. *J Arthroplasty* 1989 ; 4 : 245-251.
39. **Mulroy RD Jr, Harris WH.** The effect of improved cementing techniques on component loosening in total hip replacement. An 11-year radiographic review. *J Bone Joint Surg* 1990 ; 72-B : 757-760.
40. **Mulroy WF, Estok DM, Harris WH.** Total hip arthroplasty with use of so-called second-generation cementing techniques. A fifteen-year-average follow-up study. *J Bone Joint Surg* 1995 ; 77-A : 1845-1852.
41. **Pudenz RH.** The repair of cranial defects with tantalum : an experimental study. *JAMA* 1943 ; 121 : 478-481.
42. **Robertson RCL, Peacher WG.** The use of tantalum foil in the repair of peripheral nerves. *Surg Clin North Am* 1943 ; 23 : 1491-1504.
43. **Russotti GM, Coventry MB, Stauffer RN.** Cemented total hip arthroplasty with contemporary techniques. A five-year minimum follow-up study. *Clin Orthop* 1988 ; 235 : 141-147.
44. **Schmalzried TP, Harris WH.** The Harris-Galante porous-coated acetabular component with screw fixation. Radiographic analysis of eighty-three primary hip replacements at a minimum of five years. *J Bone Joint Surg* 1992 ; 74-A : 1130-1139.
45. **Stauffer RN.** Ten-year follow-up study of total hip replacement. *J Bone Joint Surg* 1982 ; 64-A : 983-990.
46. **Sutherland CJ, Wilde AH, Borden LS et al.** A ten-year follow-up of one hundred consecutive Muller curved-stem total hip-replacement arthroplasties. *J Bone Joint Surg* 1982 ; 64-A : 970-982.
47. **Unger AS, Lewis RJ.** Cementless acetabular revision using trabecular metal. *69th Annual Meeting of the American Academy of Orthopaedic Surgeons* 2002 ; Dallas, TX.
48. **Zhang Y, Ahn PB, Fitzpatrick DC et al.** Interfacial frictional behaviour : cancellous bone, cortical bone, and a novel porous tantalum biomaterial. *J Musc Res* 1999 ; 3 : 245-247.