Clinical Article

The results of a cementless acetabular component combined with impaction bone grafting in patients with acetabular protrusion

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Abstract

We undertook this study to determine the results of acetabular fixation using the Duraloc 300 uncemented acetabular component combined with impaction bone grafting in patients with acetabular protrusion. Forty-two consecutive total hip replacements using a Duraloc 300 cup in patients with acetabular protrusion requiring impaction bone grafting were reviewed at an average of 6.3 years. In no cases were structural graft, wire mesh or cages utilised. Pre-operative X-rays were analysed for degree of protrusion. Post-operative X-rays were analysed for cup placement including centre of rotation and interface gaps. Follow-up films were analysed for graft incorporation, lucent lines, osteolysis, wear and migration. Kaplan-Meier survivorship analysis was performed. All components were found to be stable. Two components moved in the immediate post-operative period, but both components stabilised within six months of surgery and have remained stable for seven and eight years respectively. Incorporation and remodelling of the bone graft occurred in all cases. Mean rate of wear was **0.19mm per year**. One case of pelvic osteolysis was seen. The Duraloc 300 cup provides excellent fixation in patients with acetabular protrusion and impaction bone grafting and fixation can be achieved without the use of structural graft, wire mesh or cages. We are therefore optimistic that the durability of fixation should equal that of primary hip surgery without protrusion.

Key words: Protrusion acetabulum, protrusio acetabuli, acetabular bone loss, acetabular management, hip arthroplasty

Introduction

Adequate results have been achieved with cemented components combined with impaction bone grafting in patients with acetabular protrusion.[1-4] However due to the excellent fixation achieved using the Duraloc 300 cementless acetabular component in routine total hip replacement we have used the Duraloc 300 in all cases of acetabular protrusion since October 1992.[5]

The key aspects in the management of acetabular protrusion (with a non-cemented implant) are recreating an anatomical centre of rotation in conjunction with achieving an immediately stable press fit fixation. Some authors have recommended that the cup be placed in the true acetabular region to improve the long-term survival of the implant.[3,6,7]

On the basis of a mathematical model of the hip joint, Johnston *et al*. found that 'placement of the centre of the acetabulum as far medially, inferiorly, and anteriorly as is anatomically possible is of prime importance in reducing the loads at the hip'.[8] Increased rates of loosening of both the femoral and the acetabular component have been associated with an initial position of the acetabular cup outside of the true acetabular region.[3,6,7] Conversely, other authors have suggested that superior placement of the cup without concomitant lateral displacement has no detrimental effect on the longevity of the prosthesis.[9,10] Proximal placement of the cup is usually unavoidable as it is difficult to place bone graft superiorly and achieve a stable press fit. However it is possible to seat the component anatomically in the medial/lateral plane by impacting medial bone graft and relying on peripheral fit for stability. A number of authors have shown that bone graft placed medially to the acetabular component reliably incorporates and remodels over a period of time.[2,4,6,11] We specifically assessed the process of incorporation and remodelling of the bone graft in relation to the placement of the acetabular component. The centre of rotation of the acetabular component was calculated to assess how accurately the anatomical centre of rotation was recreated, for any relationship between the centre of rotation, the longevity of the components and the outcome of the bone graft.

The purpose of this study was to evaluate our results in order to establish whether the use of this component in combination with impaction bone grafting in acetabular protrusion was justified. To our knowledge no previous papers have been published with an average follow-up of 6.3 years using a Duraloc 300 cementless acetabular component in acetabular protrusion.

Patients and methods

The Duraloc 300 (De Puy, Warsaw, USA) is a three-pegged, less than a hemisphere, porous coated titanium component (*Figure 1*). The Porocoat has an average pore size of 250 microns, to optimise penetration by bone tissue.[12] The three stabilising pegs offer additional rotational security.

Forty-two total hip arthroplasties were carried out in 32 female patients and four male patients. Six patients had bilateral total hip replacements. Diagnosis was osteoarthritis in four, rheumatoid arthritis in 29, juvenile chronic arthritis in two and ankylosing spondylitis in one. Mean age of surgery was 54 years (19–83). A minimum time of two years following surgery was required for inclusion in the study. Five patients died at an average of six years post surgery. None of these patients had undergone a re-operation and all had a satisfactory fixation of the acetabular cup as seen on radiographs taken on average 3.1 years after surgery. Two patients were lost to follow-up and one patient developed sepsis, leaving 34 hips available for analysis after an average duration of follow-up of 6.3 years (2–11). Degree of protrusion was assessed according to the criteria of Sotelo-Garza and Charnley.[1]

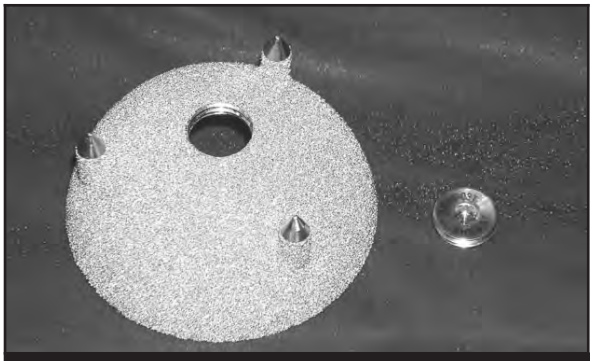

Figure 1. Duraloc 300 acetabular component and hole eliminator

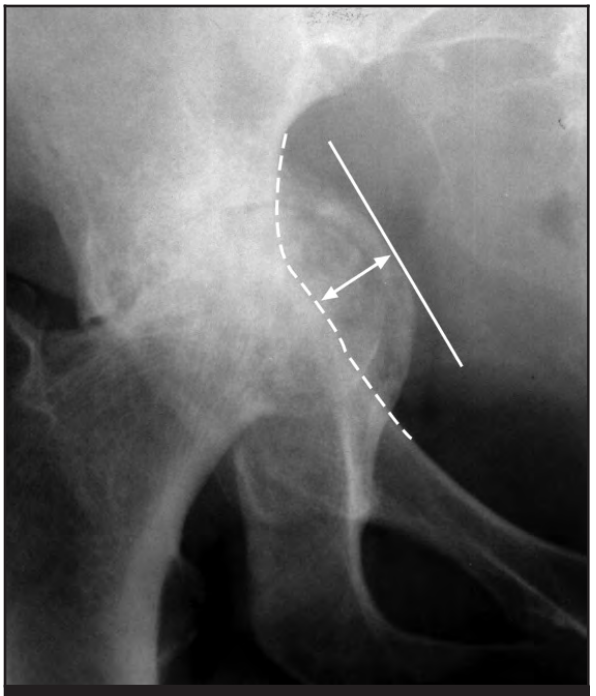

Figure 2. The degree of protrusion was assessed according to the criteria of Sotelo-Garza and Charnley.[1] This radiograph shows an example of a Grade 3 protrusion.

The rim of the pelvis, taken as a projection of the upper margin of the superior pubic ramus is used as a reference and protrusion is graded as follows: Grade 1 – mild with the hips displaced 1–5 mm into the pelvis; Grade 2 – moderate with the hips displaced 6–15 mm into the pelvis; and Grade 3 – severe with the hips displaced more than 15 mm into the pelvis (*Figure 2*). All operations were performed by the same hip surgeon. An anterolateral approach was used with the patients in a lateral decubitus position. The anterior capsule was excised and the acetabulum was reamed to remove all soft tissue and down to bleeding bone where possible.

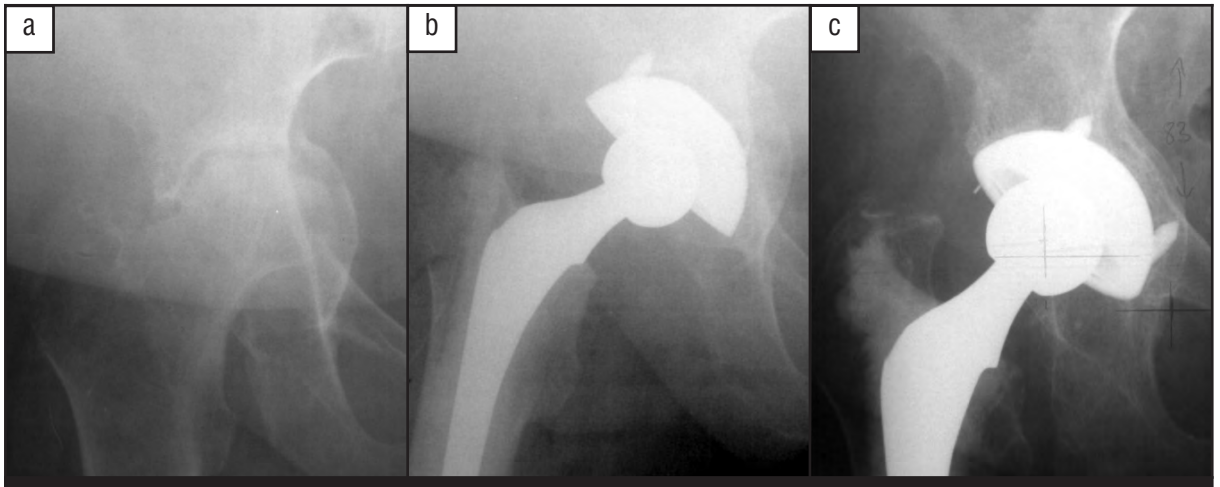

Figure 3. Example of cup placed lateral to iliopectineal line. a: Pre-operative. b: Immediately post-operative. c: Six years post-operatively.

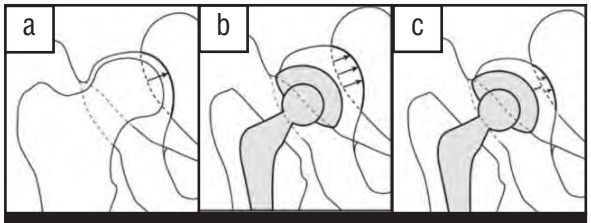

Figure 4. Bone remodelling when cup is placed lateral to iliopectineal line

A trial implant was utilised to assess how far the component could be lateralised without compromising stability. The medial space was impacted with morcellised femoral head autograft. The Duraloc 300 (De Puy, Warsaw, USA) acetabular component, with three pegs for stabilisation, less than hemispherical, manufactured of porous-coated titanium component was used in every case. The implant was impacted at an inclination of 45°, and anteversion that corresponded to that of the acetabulum. A stable construct was achieved in all cases. A 'hole eliminator' only became available for use from January 1995, and hence was not used in any cases prior to this. The polyethylene liner was inserted with the long 10° wall in the optimal position following a trial reduction. Radiographic examination was made on an antero-posterior radiograph of the pelvis. Measurements were made on the post-operative and final follow-up radiographs. Centre of rotation, cup migration, lucent lines, abduction angle, osteolysis, quantity and quality of bone medial to the cup and the polyethylene wear were assessed. All measurements were made by a single observer who had not participated in the surgery. Centre of rotation was determined using the method described by Pierchon and validated by Palazon *et al.*[13,14,15] Remodelling of the bone graft was assessed by analysing the quality and quantity of bone medial to the cup. If the cup was placed lateral to the iliopectineal line the amount of bone between the cup and the iliopectineal was measured as well as the amount of bone which remained protruding into the pelvis (*Figures 3a, b, c and Figure 4*). In cases where the cup was placed on the iliopectineal line or medial to it the amount of bone medial to the cup was measured (*Figures 5a, b, c and Figure 6*). The degree of remodelling could then be assessed in relationship to the placement of the acetabular component. Radiolucent lines were evaluated in the three zones as described by De Lee and Charnley.[16] Osteolysis was described as a circular or oval area of distinct bone loss. Evidence of migration was measured on the follow-up films and the acetabular component was considered loose if any of the following criteria were present: 1) the occurrence of radiolucent lines after two years; 2) progression of radiolucent lines after two years; 3) radiolucent lines in all three zones (even if they are not continuous); 4) radiolucent lines 2 mm or wider in any zone; and 5) migration.[17-20] Linear polyethylene wear was measured using a digital hip analysis suite.[21,22]

Results

Radiological analysis

All 34 hips showed a well-fixed component at the time of latest follow-up. Two components lost position within three months of surgery. The angle of inclination increased from 44° to 60° and from 50° to 66° respectively. Comparison of the radiographs taken at three months to the final follow-up radiograph taken at 8.1 and 6.8 years for each case revealed no further loss of position. In neither of these cases was any lucency seen around the acetabular component on any of the follow-up radiographs. Therefore both these components were considered to be well fixed in their final positions.

All 34 hips showed a well-fixed component at the time of latest follow-up

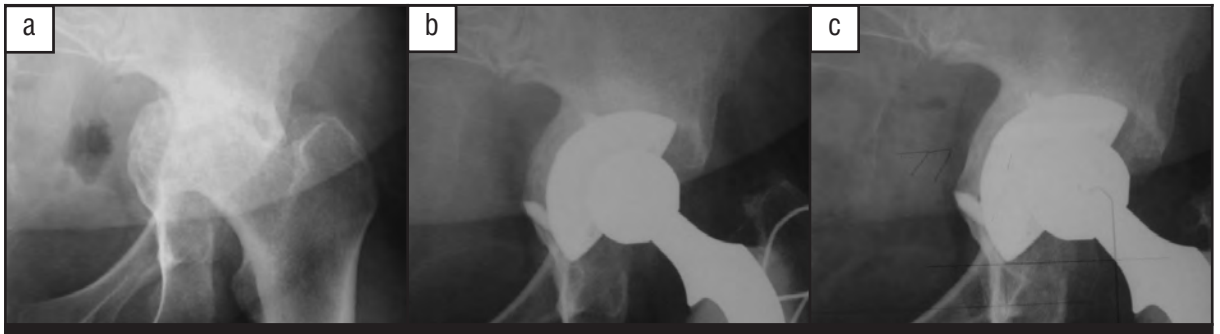

Figure 5. Example of cup placed medial to iliopectineal line. a: Pre-operative; b: Immediately post-operative; c: Eight years post-operatively.

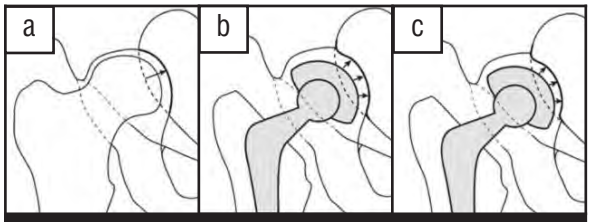

Figure 6. Bone remodelling when cup is placed medial to iliopectineal line

Eight hips had a lucent zone (gap) around the socket on the initial post-operative radiograph; none had a lucency in three zones, four had a lucency in two zones and four had a lucency in one zone. All the lucencies resolved except in one patient where the lucency progressed to an osteolysis lesion in zone 2 and zone 3 around the component.

For the assessment of centre of rotation three hips were excluded: two because of component migration and one hip in a patient with ankylosing spondylitis where an adequate X-ray could not be obtained due to spinal deformity. In the remaining 31 cases, the centre of rotation was placed proximally by an average of 10 mm in 29 hips. In the remaining two hips the centre of rotation was placed 1 mm distally in both cases. In 18 hips the centre of rotation was placed medially by an average of 5 mm. In 11 cases the centre of rotation was placed laterally by an average of 3.5 mm leaving two hips where the centre of rotation was correct in the medial/lateral plane. The bone graft incorporated in all cases and the remodelling of the graft was assessed as follows. If the cup was placed lateral to the iliopectineal line the amount of bone between the cup and the iliopectineal line was measured in millimetres as well as the amount of bone extending beyond the iliopectineal line (*Figures 3a, b, c and Figure 4*). If the cup was medial to the iliopectineal line the amount of bone surrounding the metal backed cup was measured (*Figures 5a, b, c and Figure 6*). In 21 cases the cup was placed lateral to the iliopectineal line and on follow-up the average amount of bone between the cup and the iliopectineal line was 7 mm (2–13 mm). In these cases an average of 2 mm of bone extended into the pelvis (1–6 mm). The average degree of initial protrusion in cases where the cup was placed lateral to the iliopectineal line was 7.5 mm. Post-operatively these patients had on average 7.5 mm of bone graft extending beyond the iliopectineal line into the pelvis. In the 13 cases where the cup crossed the iliopectineal line an average of 5.5 mm of bone was measured medial to the cup at follow-up. The average degree of protrusion in these cases was 10 mm. In the situation where the cup was placed medial to the iliopectineal line an average 10 mm of bone graft remodelled to an average of 5.5 mm of bone at follow-up. In all cases where the amount of bone medial to the cup exceeded 3 mm the bone was corticated and trabeculated except in the case that developed osteolysis. In cases where the amount of bone medial to the cup was less than 3 mm the bone was sclerotic and it was difficult to comment on trabeculation.

Overall the mean rate of linear wear was **0.19 mm/year**. The average angle of inclination was 43° (30°–60°). Analysis showed no correlation between wear and inclination, polyethylene thickness, age of patient or diagnosis.

Component survival

No acetabular component was revised for aseptic loosening. One patient dislocated immediately post surgery. The hip was reduced and the patient mobilised routinely. This patient had a successful outcome and has had no further problems. One patient developed peri-acetabular osteolysis. The osteolysis developed in the bone graft and the patient is being considered for a bone-grafting procedure.

Discussion

Acetabular protrusion in hip arthroplasty surgery presents the surgeon with technical challenges that need to be addressed. The aim is to restore bone stock as well as the centre of rotation. Previous authors have shown that these challenges can be met utilising either solid or morcellised bone graft with a cemented component.[1-3,5] We have shown that similar results can be achieved with an uncemented component.

The advantage of an uncemented component is modularity. The liner can be exchanged in a well-fixed component for excessive wear or instability. Cemented components have generally been shown to have less polyethylene wear. We are hopeful that newer bearing surfaces will make this less of a problem in the future.

We have shown that a secure fix can be obtained in acetabular protrusion with an uncemented component that appears to be durable. We did however have two cases where the component lost position in the early post-operative period. Although the situation stabilised and revision surgery was not required, this should not occur. These were very severe cases with extensive bone loss and the stability was incorrectly assessed at the time of surgery. Both of these cups should have been stabilised with extra screw fixation.

We did not always achieve a normal centre of rotation and this did not appear to lead to failures for the duration of this study. When the cup is placed lateral to the iliopectineal line the bone graft that extended into the pelvis remodels more considerably than when the cup is placed medial to the iliopectineal line. This may be explained by Wolff's law of bone remodelling. If the cup is placed lateral to the iliopectineal line, the bone which extends medially into the pelvis would not be critical for fixation and would be resorbed. If the cup is placed medial to the iliopectineal line the bone medial to cup is constantly stressed and would therefore not be resorbed. If the cup is placed lateral to the iliopectineal line the bone graft between the cup and the iliopectineal line was shown to incorporate and remodel and resemble a normal pelvis. In those patients where a normal hip centre was achieved, extensive remodelling of the bone stock occurred with the follow-up X-ray showing little evidence of the original protrusion. We therefore feel that a normal hip centre should be aimed for with a restoration of hip biomechanics. Careful pre-operative templating would assist in achieving this goal.

A shortcoming of this study is that we did not correlate the results with a clinical assessment. It is possible that the position of the hip centre could influence the gait pattern and long-term outcome. A cup that has been placed medially will shorten the body weight lever arm and theoretically decrease the forces across the hip joint which is advantageous. This of course will be at the expense of medial bone stock. A normal hip centre would restore normal biomechanics and muscle function. Long-term clinical and radiological follow-up will be required to provide a better understanding of the problem.

This study has shown that a porous cementless cup inserted with a press-fit technique provides excellent results in conjunction with impaction bone grafting in consecutive cases of acetabular protrusion for up to six years.

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