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ORIGINAL ARTICLE • HIP - ARTHROPLASTY

Revision hip arthroplasty using impacted cancellous bone and cement: a long-term follow-up study

Gowthaman Arumugam[1] · Shashi Kumar Nanjayan[2] · Conal Quah[3] · Philip Wraighte[4] · Peter Howard[5]

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Abstract Acetabular bone deficiency is one of the many challenging problems encountered in revision hip arthroplasty. A variety of surgical options and techniques are available including impaction bone grafting. We present our long-term experience of 68 consecutive cups in 64 patients, using impacted cancellous bone grafting with bone cement. With a mean follow-up of 10.5 year (IQR 7.5–12.9) after revision surgery, three implants had undergone further revision. Three patients had subsequent femoral peri-prosthetic fractures, and none of these three required further acetabular revision. Survival of the acetabular components was 95.5 % for all causes and 100 % for aseptic loosening as the end point, with a further four patients showing radiographic, but asymptomatic loosening. A significant correlation was found between previous revision and re-revision (early failure) ($p = 0.01$) as well as progression of lytic lesion and re-revision ($p = 0.01$). The median Harris hip score at final follow-up was 79.5 (IQR 67.9–80.4). The use of impacted morcellised allograft bone with a cemented cup is an effective technique to achieve longevity and restoration of bone stock in acetabular revision arthroplasty. Our series has shown good clinical and radiological outcome with survivorship of the prosthesis exceeding 95 % at 10 years.

Keywords Impaction bone grafting · Revision arthroplasty · Morcellised allograft

✉ Conal Quah
conalquah@yahoo.com

Gowthaman Arumugam
drgowtham@gmail.com

Shashi Kumar Nanjayan
shashikumartn@gmail.com

Philip Wraighte
pjwraighte@yahoo.co.uk

Peter Howard
peter.howard@nhs.net

[1] University Hospitals of North Midlands NHS Trust, Stoke-on-Trent, UK

[2] King's Mill Hospital, Sutton-in-Ashfield, UK

[3] Royal Derby Hospital, Derby, UK

[4] St Richard's Hospital, Chichester, UK

[5] Royal Derby Hospital, Derby, UK

Introduction

Acetabular bone deficiency secondary to osteolysis and mechanical instability presents as one of the most challenging problems during revision hip arthroplasty. There are a variety of surgical options and techniques available to address this problem including the use of impacted cancellous bone to augment the bone stock in combination with a cemented acetabular prosthesis [1–4]. Femoral impaction bone grafting with cement has been shown to be a successful technique [5], but, less data is available for acetabular outcome.

The purpose of this study was to evaluate the long-term clinical and radiographic outcomes of revision acetabular components with impacted cancellous bone graft reconstruction and a cemented polyethylene cup in patients with acetabular bone deficiency.

Patients and methods

Between 1993 and 2000, 72 consecutive patients underwent acetabular revision arthroplasty with impaction cancellous bone grafting and cemented polyethylene cup, at

our institution. There were two patients who died within 2 years of the revision operation of unrelated causes, and there were two patients who were lost to follow-up.

The remaining 68 hip revisions in 64 patients were performed by two senior arthroplasty surgeons, 57 of which by the senior author. There were 29 men and 35 women, with a mean age of 69.9 (±10.2 years) at operation. There were 32 were right hips, 28 left hips and 4 bilateral. Cases were selected on the basis of clinical suitability for the technique and defects being contained or semi-contained (includes flimsy bone on the acetabular rim with intact soft tissue). The depth of cavitary lesions was not considered, but a graft depth of about 1 cm around most of the periphery was felt to be desirable. Pelvic discontinuity was considered to be a contra-indication.

The mean follow-up was 10.5 years. There were 60 hips that were revised for failed primary total hip arthroplasty (THA) and 8 hips that had already been revised previously. The commonest primary acetabular component revised was the Charnley cup (34 hips). Others included the Aesculap, Muller and Stanmore prostheses.

The indications for revision surgery were aseptic loosening (56 hips), septic loosening (6 hips), recurrent dislocation (4 hips) and stem fracture (2 hips).

There were 17 hips that underwent revision of acetabular component only and 51 hips that had concomitant revision of the femoral prostheses. In 14 cases, reconstruction of the acetabular defect was performed with either the Burch-Schneider ring (Zimmer, Warsaw, Indiana), Ganz reinforcement ring or Eichler ring (Zimmer). Preoperative X-rays were available to assess bone stock in all but 15 patients.

Four brands of cemented acetabular components were implanted at revision arthroplasty:

DePuy Elite Plus (Thackray, Leeds, England)	25 (6 Ogee)
Charnley cemented cup (Thackray, Leeds, England)	28 (12 Ogee)
Cenator (Corin Group, Gloucester, England)	14
Exeter Contemporary (Stryker Howmedica Osteonics)	1

Operative technique

The posterior approach was used to perform the revision procedures, and where possible the previous surgical scar was utilised. The component and any previous cement were carefully removed, with thorough debridement of all granulation tissue from the bony surface. Morcellised allograft obtained from the Bone Bank at our institution (femoral heads harvested locally, frozen and not irradiated) was then impacted into the acetabular defect using impactors. The bone was prepared as a mixture of crouton-sized cancellous chips (about 0.5 cm) with a bone nibbler and finer cortical chips through a bone mill. The allograft was thoroughly washed prior to impaction into the acetabulum, filling all defects and covering all host bone. Mesh was only used if the acetabular defect breached the floor or wall of the acetabulum extensively. The acetabular component was then cemented in place using either antibiotic-loaded Palacos RG (Heraeus Medical GmBH, Hanau, Osteonics) or Simplex (Stryker Howmedica, Osteonics).

Antibiotic prophylaxis was provided by intravenous cefuroxime (1.5 g) at induction and two further post-operative doses of 750 mg at 8-h intervals. Thromboprophylaxis involved arteriovenous impulse boot and TED stockings and the administration of either adjusted low-dose warfarin (57 procedures) or calcium heparin. Patients were mobilised touch weight bearing with crutches for six to eight weeks followed by progressive weight bearing over a similar duration of six to eight weeks.

Radiological evaluation was performed on pre-operative, immediate post-operative, 1-year post-operative and final follow-up visits using anteroposterior and lateral radiographs centred on the hip joint. For those patients who died during the follow-up period, the most recent radiographs before death were evaluated.

Pre-operative bone loss was graded according to the Paprosky and AAOS classification [6, 7] (Tables 1, 2).

(Paprosky classification: type 1—minimal deformity, intact rim; type 2A—superior bone lysis with intact superior rim; type 2B—absent superior rim, superolateral migration; type 2C—localised destruction of medial wall; type 3A—bone loss from 10 am to 2 pm around rim, superolateral cup migration; type 3B—bone loss from 9 am to 5 pm around rim, superomedial cup migration)

This was confirmed again during the revision procedure. Radiolucent lines in the Charnley acetabular zones [8], graft–host bone incorporation, initial inclination and change in inclination of the acetabular component as well as migration were all recorded. Variations in magnification were corrected using the known diameter of the femoral head as an internal reference.

The patients were reviewed annually. The Harris hip score (HHS) was used to assess clinical outcome [9].

Table 1 The number of revision cases as per AAOS classification of pre-operative bone stock loss

AAOS	1	2	3	4
No. of hips	1	16	28	8

Table 2 The number of revision cases as per Paprosky classification of pre-operative bone stock loss along with the type of reinforcement rings used

Paprosky	1	2a	2b	2c	3a	3b
No. of hips	3	1	4	9	26	10
No. and type of ring			1 Ganz		9 Ganz	1 Ganz
$n = 14$			1 Eichler		2 Burch-Schneider	

Statistical analysis

Analysis of the data was carried out using SPSS softwre (SPSS Inc., Chicago, Illinois). Pearson's Chi-square test was used to evaluate pre-operative bone stock (Paprosky and AAOS classification), progression of radiolucency, migration and re-revision. The relationship between acetabular inclination, lytic zone progression and re-revision was assessed using ANOVA and Fisher's exact test, respectively. Correlation between patients with a previous infection and further revision was evaluated using Chi-square test. Survivorship analysis with any further revision and symptomatic loosening as the end point was assessed. A "p value" ≤ 0.05 was considered to be statistically significant.

Results

There was a minimum of 10-year follow-up in 50 out of 68 patients. There were 18 patients who had died of unrelated cause to the hip operation. The minimum follow-up for these 18 patients was 7.5 years, and the radiographs and data available before the death or revision were used for the analysis of data.

Tables 1 and 2 summarise the distribution of acetabular defects encountered in this study. The average inclination of the acetabular component was 47 [interquartile range (IQR) 45–50]. Six of the 68 patients showed progression of radiolucent zones between the follow-up X-rays, and two patients out of these patients went on to have revision surgery (both for deep infection). Incorporation was judged by establishment of trabecular pattern between the graft and host bone interface in 188/204 Charnley zones (92 %) (Fig. 1a–c).

At the mean follow-up of 10.5 years (IQR 7.5–12.9) after revision surgery, three implants had undergone further revision procedure: one was for recurrent dislocation, and two for late onset deep infection. Two of these three patients had undergone previous revision surgery. Three patients had subsequent femoral peri-prosthetic fractures, of which one had fixation with plate and screws and two had the femoral component revised. None of these three required further acetabular revision.

Kaplan–Meier survivorship analysis predicted that a rate of survival of the acetabular components at mean 10.5-year follow-up was 95.6 % (95 % CI 94–99) for all causes and 100 % for aseptic loosening as the end point (Fig. 2), with a further four patients showing radiographic, but asymptomatic, loosening. These patients with radiographic loosening had poor acetabular bone stock pre-operatively (AAOS type 3 or Paprosky type 3a and type 3b of acetabulum defects).

There was a statistically significant correlation between previous revision and re-revision (early failure) ($p = 0.01$) and progression of the lytic zone and re-revisions ($p = 0.01$). No statistical significance was found between degree of inclination of the cup, previous infection and re-revision ($p = 0.64$).

A repeat HHS was available in 45 of the 68 patients at the final follow-up. The median score at the 10.5-year (IQR 7.5–12.9) follow-up was 79.5 (IQR 67.9–80.5).

Discussion

Acetabular bone loss can be a challenging problem in revision total hip replacement. A variety of operations and techniques have been described in the past to achieve the primary (and hence long term) stability and restoration of bone stock—two of the main goals. These include cemented [3, 10, 11] and uncemented cups [12–14], augmented with different grafting techniques and hardware. Reconstitution of deficient acetabular bone stock is emphasised by Slooff [15] and Azuma [16] who reported good outcomes. The objective is to achieve overall construct stability with the use of cement, and the subsequent bone ingrowth results in restoration of living bone stock. Favourable results have been published for impaction bone grafting in the femur using cement [5, 17–19]. We report a successful outcome in our series with survival of the acetabular component of 95.5 % [95 % CI 94–99] at 10 years by following this principle and restoring the bone stock. The longest follow-up comes from Schreurs et al. [20, 21] who reported their results at a follow-up period of 2, 5.7, 11.8 and 15–20 years, with a favourable outcome with a survival rate of 79 % (95 % CI 67–93) at 20-year follow-up [22]. Schreurs et al. [20, 21] reported a revision rate of 4.5 % at 10- to 15-year follow-up. Comba et al. [23] report the similar revision rate of 4.5 % in a series of 142 patients over a period of 4 years with an overall survival rate of 95.8 % (95 % CI 92.3–99.1).

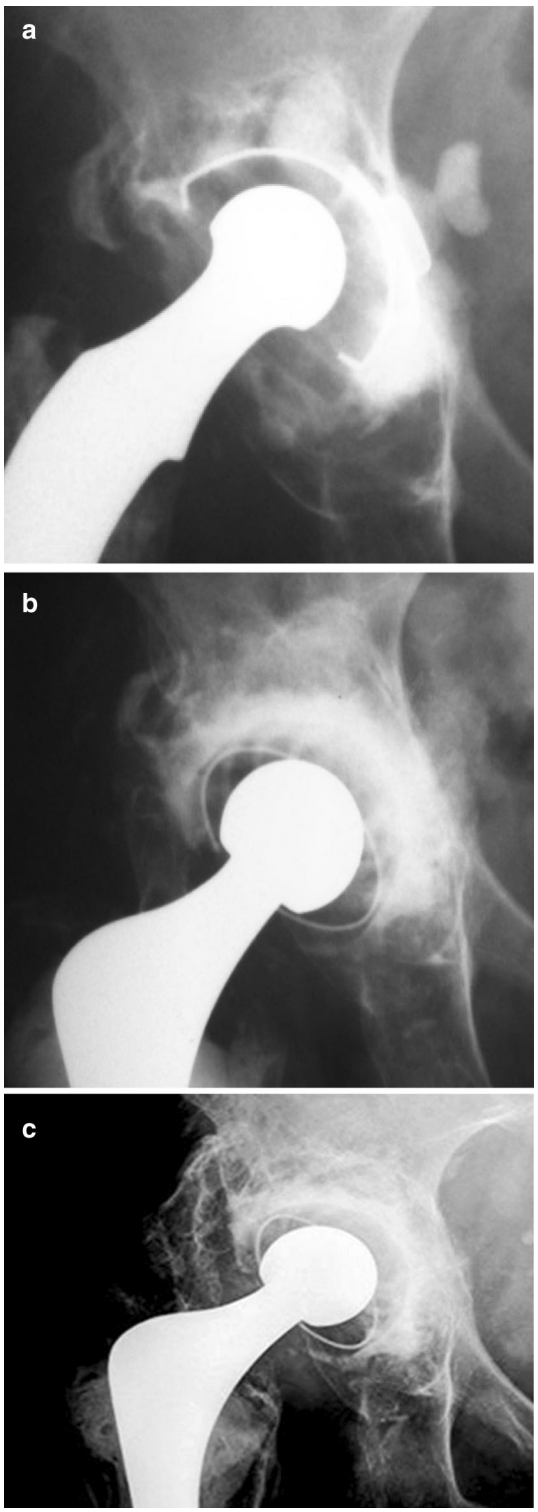

Fig. 1 **a** Pre-operative radiograph of patient with aseptic loosening of acetabular cup with cavitary defect and acetabular protrusio. **b** Post-operative radiograph at 6 weeks demonstrating impaction grafting and cemented acetabular prosthesis restoring the centre of rotation. **c** Radiograph demonstrating graft incorporation and good acetabular cup position at 11 years post-surgery

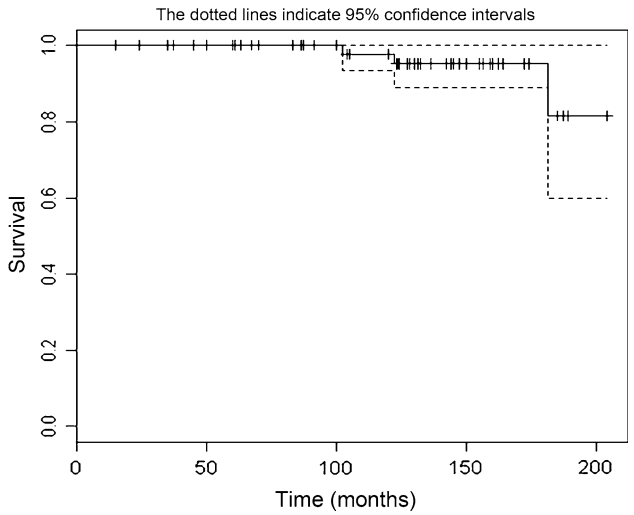

Fig. 2 Kaplan–Meier survivorship analysis predicted a rate of survival of the acetabular components at a mean of 10.5-year follow-up was 95.6 % (95 % CI 94–99) for all causes and 100 % for aseptic loosening as the end point

The use of cementless "jumbo", "bilobed" and "oblong" cups has shown similar or less favourable results compared to this series [24–28], but by virtue of the technique the restoration of bone stock is less necessary with these methods. Trabecular metal cups which are made from tantalum, offer the promise of improved primary stability as it provides excellent initial scratch fit. It also has up to 80 % porosity, increasing the potential for bone integration, bone remodelling and vascularisation. There are currently no long-term studies looking at the use of trabecular metal in revision hip arthroplasty [29–31]. A study by Moličnik et al. [34] evaluated early functional results of revision hip arthroplasty with pelvic bone loss with porous tantalum acetabular components. Good clinical outcomes of 25 consecutive patients were demonstrated at a mean of 20.5-month follow-up with no septic or aseptic failures in this series.

In our reported series, the functional HHS of 79.5 (IQR 67.9–80.45) was good, and the appearance of graft incorporation and long-lasting fixation were encouraging. There were three failures (4.4 %) in our series: two were due to infection and one due to recurrent dislocation. The survival of the acetabular components at a mean of 10.5-year follow-up was 95.6 % for all causes and 100 % for aseptic loosening as the end point. A comparison of the published results of various revision methods is summarised in Table 3.

This study has the limitation of being a retrospective analysis, like most similar long-term follow-ups. Case selection, particularly in terms of deciding pre-operatively

Table 3 A comparison of published results of various revision methods

Type of acetabular component	References	Series size	Length of follow-up (years)	Implant survival (%)	Comments
Oblong cementless implant	Abeyta et al. [27]	25	11	76.5	26 % radiographic loose
	Moskal et al. [26]	11	6	85	
	Koster et al. [28]	56	9	93	Three revisions due to aseptic loosening
Impaction grafting with cement	Buttaro et al. [10]	23	3	90	
	Comba et al. [23]	110	10	83.3	
	van Haaren et al. [32]	71	7	72	
	Current	68	10.5	95.5	One for recurrent dislocation and 2 for late onset deep infection. (2 out of these 3 were re-revisions)
	Schreurs et al. [20]	37	12	80	17 % radiologically loose
	Schreurs et al. [21]	56	11.8	90	
Jumbo cementless	Dearborn and Harris [24]	24	7		Five (21 %) recurrent dislocations, 5 (21 %) septic failure
	Patel et al. [25]	42	10	83	
	Palm et al. [33]	79	9	90.5	
Trabecular metal	Skytta [30]	827	3	92	
	Moličnik et al. [34]	25	1.7	100	One (4 %) cup had lucent lines, but remained well fixed
	Kim et al. [24]	37	3	98	5.4 % radiologically loose
	Siegmeth et al. [35]	37	2	94	5.4 % radiologically loose
	Flecher et al. [31]	23	3	100	
	Lakstein [36]	57	2		Two failed cups (4 %) were revised. Two additional cups (4 %) had radiographic evidence of probable loosening

what constitutes adequate primary stability, is difficult to define and makes comparison of different methods and series difficult.

In conclusion, the use of impacted morcellised allograft bone with a cemented cup is an effective technique to achieve longevity and restoration of bone stock in acetabular revision arthroplasty. Good clinical and radiological outcome has been demonstrated in this series with survivorship of the acetabular component exceeding 95 % at 10 years for all causes and 100 % for aseptic loosening as the end point.

Compliance with ethical standards

Conflict of interest None.

Ethical standard All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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