CEMENT IN CEMENT FEMORAL COMPONENT REVISION: MID-TERM RESULTS USING TWO COLLARLESS, TAPERED STEMS

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Abstract

Introduction: Cement-in-cement revision of the femoral component represents a widely practiced technique for a variety of indications. In this study we compare the clinical and radiological outcomes of two polished tapered stems.

Methods: From our prospectively collated database we identified all patients undergoing cement-in-cement revision from January 2005 – 2013 who had a minimum of two years follow-up. All cases were performed by the senior author using either an Exeter short revision stem or the C-stem AMT high offset No 1. Patients were followed-up annually with clinical and radiological assessment.

Results: Ninety-seven patients matched the inclusion criteria. There were 50 Exeter and 47 C-stem AMT components. There were no significant differences between the patient demographics in either group. Mean follow-up was 9.7 years. A significant improvement in OHS, WOMAC and SF-12 scores was observed in both cohorts. Leg lengths were significantly shorter in the Exeter group, with a mean of -4mm in this cohort compared to 0mm in the C-stem AMT group. One patient in the Exeter group had early evidence of radiological loosening. In total, 16 patients (15%) underwent further revision of the

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femoral component (seven in the C-stem AMT group and nine in the Exeter group). No femoral components were revised for aseptic loosening. There were two cases of femoral component fracture in the Exeter group.

Conclusion: Our series shows promising long-term outcomes for the cement-in-cement revision technique using either the Exeter or C-stem AMT components. These results demonstrate that cement-in-cement revision using a double or triple taper-slip design is a safe and reliable technique when used for the correct indications.

Introduction

Removal of the entire femoral cement mantle during revision hip arthroplasty increases the risk of complications, including blood loss, perforation of the femoral cortex and femoral fracture.[1,2,3] Furthermore, it increases operative time and can reduce the femoral bone stock available for component fixation or subsequent revision procedures.[1,3] Cement-in-cement femoral component revision with preservation of the original cement mantle has therefore become an attractive and widely practised technique in revision hip surgery. The technique is commonly used to assist exposure during acetabular component revision in the presence of a well-fixed cemented femoral stem. The indications have increased, however, to include correction of femoral component malposition for recurrent dislocation, leg length discrepancy, mismatch of femoral and acetabular components during revision surgery [4] and two-stage revision for infection.[5]

Biomechanical studies have further validated this operative technique. The shear strength at the cement bone interface of a completely revised cement mantle is approximately 20-30% less than that of the original cement mantle.[6] In contrast, the cement mantle following cement-in-cement femoral revision has been shown to have minimal loss of shear strength.[7] In addition, clinical studies have indicated promising early and mid-term femoral component survivorship utilising this technique.[1,3,8]

However, to our knowledge no studies have directly compared the medium-term outcomes of different femoral taper fit stems used for cement-in-cement revision. Since introducing this technique to our unit, we have used two types of polished tapered stem. We report the clinical and radiological outcomes for cement-in-cement femoral revisions performed using these prostheses.

Methods

Our prospectively collated database was analysed to identify patients undergoing revision of the femoral stem using a cement-in-cement technique from Jan 2005 to Jan 2013. Patients with less than 2 years follow up were excluded to enable a minimum of 2 years follow-up. Cement-in-cement revision of the femoral component was performed using either an Exeter (Stryker, UK) or a C-stem AMT prosthesis (Depuy Synthes, Warsaw, IN). Two different femoral components were utilised due to a change in procurement during the time period of the study. Both femoral components are collarless, polished taper stems. All Exeter femoral components were the short revision stem (44mm offset). All C-stem AMT were the high offset No 1 (41.5mm offset) implant.

All cement-in-cement revision procedures were performed by the senior author or directly under his supervision utilising a posterior approach. The standard technique used involved dislocation of the hip, removal of cement at the shoulder of the original femoral prosthesis and assessment of the cement mantle following removal of the femoral component. Cement-in-cement revision was deemed appropriate if the distal cement mantle was intact up to the level of the lesser trochanter. The proximal cement mantle was burred to permit optimal version adjustment of the new stem. Following trial reduction with the femoral component, the cement mantle was lavaged and dried and the new femoral component cemented in place with single mix of low viscosity Palacos R + G (Haraeus, Hanau, Germany) polymethylmethacrylate cement for all cases. The femoral component was inserted without a centraliser. All patients were allowed to mobilise full weight bearing as able under guidance of the physiotherapy team post-operatively. Initial post-operative radiographs were taken 48 hours following the revision procedure and included standard anteroposterior (AP) pelvis and lateral hip views.

Follow-up occurred at 2 months post-operatively and annually thereafter for all patients and included clinical and radiographic assessment as well as completion of functional outcome scores. Scores assessed were the Oxford Hip Score (OHS), Western Ontario and McMaster Universities Arthritis (WOMAC) and Short-Form 12 Question (SF-12).

Radiographic assessment was performed by two independent observers on calibrated radiographs. Initial post-operative radiographs were compared with those taken at the most recent clinical review appointment. This allowed assessment of any progressive radiographic changes. Analysis involved assessment of leg length, femoral component alignment, quality of cementation and stem subsidence. Any discrepancy in radiographic analysis was addressed by the observers re-reviewing the radiographs to reach a consensus agreement. Leg length discrepancy (LLD) was assessed utilising the inter-teardrop line as a pelvic reference and centre of the pelvic head as a femoral reference point, as has been previously recommended.[9] Cementation was graded using a modification of the technique described by Barrack *et al*.[10] We assessed both the original cement mantle and, in a modification to the Barrack classification, the new cement-cement interface. This allowed for the new cement mantle to be assessed. Stem subsidence was recorded using the method previously described by Fowler *et al*.[11]

Survivorship was recorded as time from cement-in-cement femoral revision to further revision of the femoral component. End points recorded were 1. further revision due to aseptic loosening of the femoral stem, and 2. further revision due to any cause (all cause revision).

Statistical analysis

Demographic data comparing patients in the two femoral component groups was analysed using the Chi Squared test. T-test was used for parametric data and the Mann Whitney U test for non-parametric data. A repeated measures ANOVA was done to compare WOMAC, OHS and SF12 over time. Post-hoc comparisons were performed with pre-operative levels using a Bonferroni correction factor. Survivorship was assessed using Kaplan-Meier survival curves. Analyses were conducted using Minitab (version 18) at a 5% significance level.

Results

One hundred and two cement-in-cement revisions occurred in the study period. Five patients died prior to two years follow up and so were excluded, leaving 97 patients for analysis (Figure 1). Indications for the primary THA were osteoarthritis in 74 cases (76%), rheumatoid arthritis in 13 (13%) and trauma in 10 (10%). The mean follow-up period was 9.7 years (range 2.5 – 14.5 years). Thirty-nine of the 97 patients died during the study period (mean 7.9 years, range 2.8 – 13.3). No other patients were lost of follow-up. All patients had cement-in cement femoral revision performed as their first revision procedure after primary total hip arthroplasty. Excluding hemiarthroplasties, the Charnley monoblock stem accounted for the majority of femoral components revised (68%) followed by the Howse stem (26%) and a polished tapered femoral component for the remainder (6%). The mean time from index procedure to revision was 9.3 years (range 1.2 – 22.5 years). Reasons for revision are presented in Table 1.

Table 1: Aetiology of cases undergoing cement-in-cement revision in both groups.

Reason for cement-in-cement revision	**Cumulative n (%)**	**Exeter n (%)**	**C-stem AMT n (%)**
Aseptic loosening of cup	63 (65%)	35 (70%)	28 (60%)
Dislocation	18 (19%)	12 (24%)	6 (13%)
Conversion of hemiarthroplasty	8 (8%)	2 (4%)	6 (13%)
Fracture	3 (3%)	1 (2%)	2 (4%)
Component impingement	3 (3%)	0 (0%)	3 (6%)
Metal-on-metal components	2 (2%)	0 (0%)	2 (4%)

From the 97 cases, 50 underwent cement-in-cement revision with an Exeter stem and 47 patients with a C-stem AMT. The patient demographics for both groups are shown in Table 2. There were no significant differences observed. The mean followup in patients undergoing revision with an Exeter stem was longer (10.7 years *cf* 8.7 years, $p<0.001$). This is due to the Exeter stem being used at the start of the study period prior to conversion the C-stem AMT for the aforementioned procurement reasons.

Table 2: Patient demographics for both groups.

	Exeter	**C-stem AMT**	***p* value**
% patients (n)	52% (50)	48% (47)	
Mean age (range)	70 (49 – 92)	67 (21 – 88)	p=0.181
% female (n)	39, 78%	31, 66%	p=0.194
Mean BMI (range)	27 (22 – 38)	29 (20 – 42)	p=0.422
Median ASA score	2	2	p=0.914

BMI: Body Mass Index; ASA: American Association of Anesthesiologists

Clinical outcome scores

In both groups, a statistically significant improvement compared to pre-operative level was achieved for OHS, WOMAC and SF-12 scores ($p<0.001$). There was no difference between groups for OHS ($p=0.059$), WOMAC ($p=0.426$) or SF-12 ($p=0.938$).

Radiological assessment

Comparison of radiological outcomes between the two stem groups is seen in Table 3. Pre-operative radiographs of the original cement mantle demonstrated Barrack A or B in all cases. Assessment of the new cement-cement interface on the immediate post-operative radiograph showed grade A or B cementation in 92% of Exeter stems and 98% of C stems. Analysis of radiographs at most recent review revealed one case of early femoral component aseptic loosening in the Exeter group. This was present seven years post-operatively. The patient was asymptomatic and the loosening not significant so revision has not been performed at this time. There were no cases of aseptic loosening in the C-stem AMT group. There was no difference in mean subsidence of the femoral component. There were no significant differences in femoral component alignment with the majority of patients having components in neutral alignment. Leg lengths were significantly shorter in the Exeter group, with a mean of -4mm in this cohort compared to 0mm in the C-stem AMT group ($p=0.034$). On clinical assessment, no patients were concerned about a difference in leg lengths following revision procedure.

Table 3: Radiographic analysis of both femoral components. The only significant difference was leg lengths were shorter in the Exeter group.

	Exeter	**C-stem AMT**	***p* value**
Varus **Neutral** **Valgus**	19% 81% 0%	14% 86% 0%	*p* = 0.214 *p* = 0.336
Mean subsidence	0.5 mm (0 – 1.6 mm)	0.3 mm (0 – 1.2 mm)	*p* = 0.741
Barrack A/B	92%	98%	*p* = 0.248
Mean LLD	-4mm (range - 25mm to + 13mm)	0mm (range - 24mm to + 20mm)	*p*=0.032

Survivorship

In total, 16 patients (16.5%) underwent further revision of the femoral component (seven in the C-stem AMT group and nine in the Exeter group). No femoral components were revised for aseptic loosening. In the C-stem AMT group three were revised for infection (6.4%) and four for periprosthetic fracture (8.5%). Six of the Exeter stems were revised for infection (12%), one for periprosthetic fracture (2%) and two for fracture of the femoral component (2%). Twelve patient (12.4%) suffered dislocation, and five (5.2%) underwent revision of the acetabulum only for instability. Regarding the femoral component fractures, these occurred at four and five years post-operatively. Neither case had a history of trauma. Both patients had an increased BMI (34 and 28) however these patients were not outliers with respect to this measurement. One component fractured in the mid-stem (Figure 2) whilst the other was at the neck region (Figure 3). With revision for femoral stem aseptic loosening, survival was 100% for both types of femoral component. With revision for any cause, femoral stem survival was 82% for Exeter stems and 85% for C-stem AMT. Median survival time for the Exeter was 12.4 years (95% CI 11.2 – 13.7) and 11.5 years (95% CI 10.4 – 12.5) for the C-Stem AMT. There was no evidence of a difference in survival time between the two groups (*p*=0.707). The Kaplan-Meier analysis for all-cause revision is presented in Figure 4.

Discussion

This is the first reported series, to our knowledge, directly comparing outcomes for cement-in-cement revision using two different collarless tapered stems. Over a mean of 9.7 years post-operative follow-up, no stems required revision for aseptic loosening and there was only one case demonstrating early evidence of radiological loosening at seven years post-operative. This is comparable to the results of Kumar *et al* [12] who reported outcomes at a mean of 16 months post-operative. Cnuddle *et al* [13] reported from the Swedish arthroplasty registry on cement-in-cement revisions at six years, comparing the anatomical Lubinus stem with the taper-slip Exeter. The survivorship of the Exeter was found to be superior. This suggests the taper slip stem whether double or triple in design is suitable for cement-in-cement revision.

While there is substantial evidence supporting the use of the Exeter stem as a cement-in-cement revision component, our study adds verification of this independent of results from the design centre.[8,14,15] There is little published evidence for the C-stem AMT utilised as a cement-in-cement prosthesis, although one previous study has shown excellent early survivorship.[3] Given this limitation in evidence, as well as the differences in design between the Exeter and C-stem AMT, namely a double versus triple taper, and a broader proximal shoulder in the latter which could affect implantation, a comparison between the two stems was important. Our data supports the use of the C-stem AMT and shows comparable outcomes to the Exeter stem in terms of clinical and radiographic results. Outcome scores (WOMAC, OHS and SF-12) in both groups improved significantly at all time points compared to pre-operative scores, with no difference between the two cohorts.

Radiographic analysis showed no significant difference between the femoral stem groups in terms of quality of cementation, stem alignment and component subsidence. There was a statistically significant difference in leg lengths between the groups with a trend towards leg length reduction in the Exeter group. The cause for this is not clear but may be a reflection on the sample of primary THA's within this group.

Berstock *et al* examined the compatibility of different revision femoral components with the original cement mantle when a cement-in-cement revision was performed.[16] They found the C-stem produced a cement mantle with the most revision options, and the C-stem system presented the greatest compatibility with itself. Conversely, revising in to a CPT cement mantle with a different system required significant removal of distal cement given the shortness of the stem. In our study cohorts, the majority of stems revised were Charnley and Howse stems which have a narrow shoulder region compared to the newer C-stem AMT with its higher and straight lateral shoulder. However, our study reports that the C-stem AMT produced a mean leg length discrepancy of 0mm, suggesting the new stem remains a good option for revision. It is possible that with increasing experience with cement-in-cement revision it became apparent that it is safe to remove a significant amount of the proximal cement mantle as far as the lesser trochanter so permitting accurate stem placement and reduction in the leg length discrepancy.

There were two femoral component fractures in the Exeter group at four and five years post-operatively. Both patients had no history of preceding trauma. The manufacturer analysis did not highlight any component faults. In one patient, the femoral component was in a varus position following cement-in-cement revision and there was only a thin cement mantle in the calcar region. The patient had a BMI of 34 and developed a mid-stem fracture of the femoral component. Similar component failures have been reported in the literature, with risk factors identified being patient weight, bone density, varus stem, inadequate medial cement and small cross9sectional area of the stem.[17,18] Proximal loosening has also been postulated, as this can lead to a stress-riser at the point where the stem is firmly fixed.[19] This case could therefore potentially be attributed to the thin calcar cement mantle, high patient weight and use of the short revision stem. This highlights the importance of cement mantle assessment, operative technique and optimisation of femoral component size for the individual patient when cement-in-cement revision is performed. The other stem fracture occurred at the neck region of the prosthesis. The implant was well aligned with satisfactory cementation, and the patient had a BMI of 28. In primary femoral components, this mode of failure has been associated with the use of elongated femoral heads.[18] In our own case, a standard head was inserted. Other authors who have identified fractures in this region of the prosthesis have postulated the aetiology to be the guide hole presenting an area of relative weakness that can lead to mechanical failure.[19] This may be the cause in this case. We had a cumulative re-revision rate of 16.5%. The majority of these revisions (9/16) were performed for infection. Although comparatively higher compared to primary THA, these results are in keeping with that of other authors [20 – 22] and serve to highlight the challenging nature of revision surgery. Although there was a higher infection rate within the Exeter group, this is likely to be a result of small sample size bias as there were no variables aside from implant choice, such as indication for revision or cement type, that could otherwise explain these findings.

There are limitations with this paper. Firstly, our sample size was not large. This is offset by the advantages of the study being a single surgeon series with a long follow-up period. Although all data was collected prospectively, there was no randomisation of patients the stems being utilised which used as per local procurement reasons. Despite this, the two cohorts were comparable in terms of age, sex and BMI. The follow up period for the Exeter stem was longer reflecting the adoption of the Exeter stem for cement-in-cement revision procedures prior to the Cstem AMT. The C-stem AMT group may therefore have benefitted from greater surgeon experience with the surgical technique of cement-in-cement revision compared to the Exeter stem group. As all complications and re-revisions occurred prior to eight years post-operative in both groups, we believe this disparity will not cause any difference in outcomes as a direct result of differing follow-up duration.

Conclusion

Our series shows promising long-term outcomes for the cement-in-cement revision technique using either the Exeter or C-stem AMT components. We found no cases of revision for aseptic loosening and significant improvements in outcome scores. While component failure occurred in two cases, it is an unusual complication in hip arthroplasty and likely represents a multifactorial aetiology. These results demonstrate that cement-in-cement revision using either a double or triple taper-slip design is a safe and reliable technique when used for the correct indications.

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Figure 1: CONSORT flow diagram of patient inclusion criteria

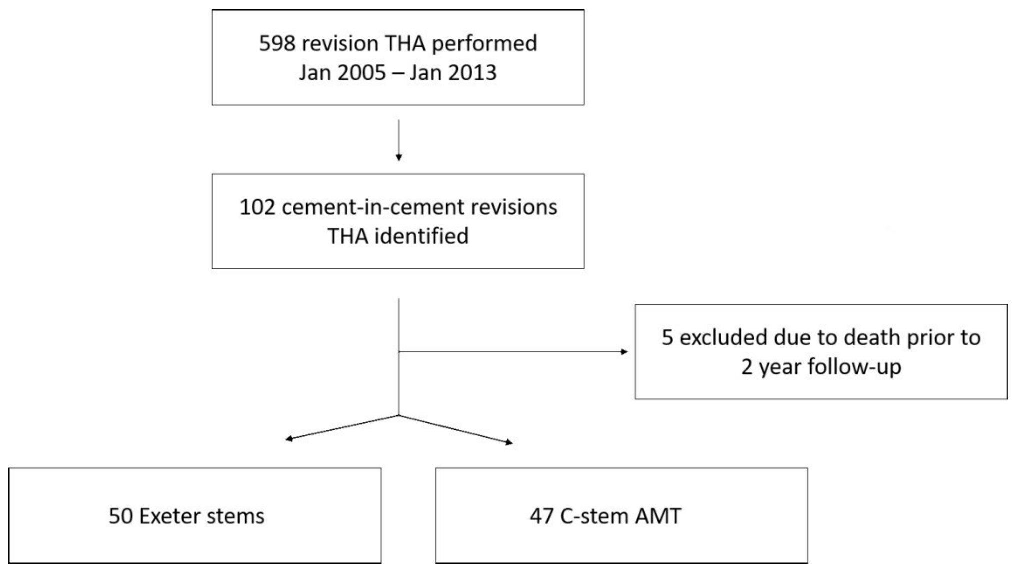

Figure 2: A case of mid-stem fracture in the Exeter group. This occurred in a patient with a BMI of 34. The calcar region was noted to have only a thin cement mantle, the stem was in a slightly varus postion and the short Exeter revision stem was used. All of these factors may have contributed to the implant fracture

Figure 3: A fracture through the neck of the implant in the Exeter group. In contrast to the previous case, this occurred in a patient with a BMI of 28 and the implant was well cemented in a neutral position. A standard head size was used. There were no clear risk factors for failure in this case, aside from the potential weak area that the implant guide hole presents. [19]

Figure 4: Kaplan-Meier analysis for all cause revision. There was no difference in the median survival between the Exeter and C-stem AMT groups (p=0.707).