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## Results of extensively coated femoral stem in revision hip replacement

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### Abstract

**Introduction:** Revision hip replacement following failed previous hip arthroplasty or internal fixation (dynamic hip screw for intertrochanteric fractures) presents a major surgical challenge. Proximal fitting revision stems do not achieve adequate fixation. Distal fixation with long-stemmed extensively coated cementless implants (like the *Solution*<sup>TM</sup> system) affords a suitable alternative. We present our results of 25 patients treated with extensively coated cementless revision stems.

**Materials and Methods:** Twenty five patients with severely compromised proximal femora following either failed hip arthroplasty or failed internal fixation (dynamic hip screw fixation for intertrochanteric fractures) were operated by the senior author over a two-year period. six patients had aseptic loosening of their femoral stems following cemented hip replacements, with severe thinning of their proximal cortices and impending stress fractures. Ten patients had secondary hip arthritis following failure of implants for comminuted intertrochanteric or subtrochanteric femoral fractures. Nine patients had peri-implant fracture following previous primary hip replacement. All patients were treated by removal of implant (cemented or uncemented stems/DHS implants) and insertion of long-stemmed extensively coated cementless revision (*Solution*<sup>TM</sup> DePuy, Warsaw (IN), US) stems along with press-fit acetabular component (Duraloc Cup, DePuy, Warsaw (IN), US). Nine patient with peri-implant fracture and five having compromised proximal femora after inter trochanteric fracture needed osteotomy and undergone encercage wiring. One patient had protrusion of acetabular cup with deficient acetabular wall in which anti protrusion cage was used.

**Results:** All patients were primarily kept in bed on physiotherapy for six weeks and then gradually progressed to weight-bearing walking over the next six to eight weeks. The Harris Hip Scores and patient satisfaction were used for final evaluation. We achieved good results in the two years duration of study. Out of 25 patients, cerclage wiring was done for peri-implant fractures and osteotomy in 14 patients. One patient had an intraoperative fracture extending into subtrochantric area while hammering in the stem. Post cerclage wiring, she was put on a long knee brace and her mobilization was delayed to 12 weeks.

**Conclusions:** The extensively coated cementless (*Solution*<sup>TM</sup>) femoral stem provides a reasonable 'solution' to the deficient femur in hip revision. The proximal femoral deficiencies can be relatively easily addressed and distal fixation can be achieved with this stem. Extreme care needs to be taken to avoid fractures and penetration of the femoral shaft, which can, however, be managed by cerclage wiring. successful outcome can be assured by preservation of the functional continuity of the abduction apparatus, care to recognize and prevent distal extension of fracture while inserting the stem and supervised gradual rehabilitation post operatively.

**Keywords:** Cementless fixation, extensively coated, proximally deficient femur

### Introduction

Total hip arthroplasty (THA) offers a reliable treatment option that relieves pain and improves function in elderly patients with end-stage arthritis of the hip. Middle-aged and young patients with hip arthritis, however, present a challenge because their expected lifespan is long and in general, the results of THA are time-limited. As the frequency of primary THA increases, the possibility of high revision incidence rates within the next decade seems very real.

Over the last generation, arthroplasty surgeons have repeatedly utilized cement as the grout for both the acetabulum and femur. When considering having THA surgery for the second or third time, concerns arise about the outcome. Revision increases the surgical and medical challenges. With revision, higher rates of second and third revisions (re-revisions), periprosthetic fractures, dislocations and septic and aseptic osteolysis are expected. Total hip

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arthroplasty done with cemented femoral components have shown long-lasting reproducible results in the elderly population, but younger patients often have poor results. In an attempt to improve longevity, particularly in younger patients, cementless femoral components have been used. The majority of these devices have a porous coating on their surface that allows for the in growth of bone and fibrous tissue into its interstices. It is hypothesized that this method of fixation allows for a more durable reconstruction than offered by cementation. There are devices that have porous coating only on the proximal portion of the stem and gain purchase in the femoral metaphysis and there are extensively coated stems that obtain purchase more distally at the femoral isthmus - all of these provide 'biologic fixation'. Revision hip replacement in proximally compromised femurs presents a significant surgical challenge. Proximal fitting revision stems do not achieve adequate fixation. Distal fixation with long-stemmed extensively coated cementless implants like the *Solution*<sup>TM</sup> stem (DePuy, Warsaw [IN], US revision hip system) affords a viable solution. However, in femoral stems with extensive proximal deficiency (such that distal scratch fit of 5-7 cm is not possible) or with patulous medullary canals, viz. Paprosky Type IIIb and IV defects, one may have to consider alternatives.

We present here our results of 25 patients with proximally deficient femora (following failed cemented total hip replacements or failed internal fixation for intertrochanteric fractures), peri-implant fracture treated with revision total hip arthroplasty (using extensively coated cementless revision stems).

### Materials and Methods

Between march 2016 and may 2018, consecutive hip arthroplasty procedures using extensively coated femoral components were performed in 25 patients (12 women and 13 men). The mean patient age at operation was 59.7 years (range, 45-75 years). In the initial surgery, fifteen of the hips had been diagnosed as hip osteoarthritis, primary or secondary, for which eight had undergone cemented THA and seven undergone uncemented THA. The primary diagnosis of the remaining ten was a intertrochanteric fracture fixed with dynamic hip screw (DHS) with either implant failure or secondary hip arthritis.

In the six hips that underwent revision surgery, the diagnosis was aseptic loosening of the previous femoral component (all cemented THAs) with severe thinning of the proximal femoral cortices and radiological evidence of impending fractures. In the 8 hips, peri-prosthetic fracture was found due to lysis around femoral stem. One patient had protrusion of acetabular cup with deficient acetabular wall for which anti-protrusion cage was used. The ten DHS-fixed hip fractures had failed by implant cutout and had an unsalvageable femoral

head in six cases, nonunion in three cases and avascular necrosis, with subsequent secondary hip osteoarthritis in one case. All patients had additional co-morbid medical factors, including diabetes mellitus (six patients), hypertension (10 patients), renal disease (one patient), ischemic heart disease (four patients) and chronic obstructive airway disease (two patients).

Preoperative radiographs of the pelvis with both hip (anteroposterior and lateral views) were obtained to estimate the length and diameter of the stem in order to obtain a scratch fit between 4 and 6 cm of the cortical bone. All operations were performed through the posterior approach. Encerclage wiring was done in patients having peri-implant fracture and patients undergone osteotomy. A straight femoral component was used in all cases - '*Solution*<sup>TM</sup>' a modular femoral component (DePuy, Warsaw [IN], US), that has extensive porous coating, modular, with a 28-mm head. The most commonly used components were 200 mm long ( $n = 14$ ) and 13.5 mm in diameter ( $n = 10$ ). Other components used were the straight 135 mm long ( $n = 1$ ) and 15 mm diameter ( $n = 4$ ), 16.5 mm diameter ( $n = 1$ ) stems. The acetabular component was also press-fit. We used the Duraloc cup (DePuy, Warsaw [IN], US) in all cases and adjunctive fixation was achieved with screws (needed in three cases). antiprotrusion ring was required in one case with deficient acetabular wall.

Patients were evaluated preoperatively and postoperatively using Harris Hip Scores (with special emphasis on the ability to walk unaided without a limp) and patient satisfaction with the procedure using a visual analog scale [VAS] model. Patients were directly questioned at the most recent visit for the presence or absence of thigh pain. Radiographs at each follow up included anteroposterior (AP) and lateral views of the femur and these were compared with radiographs obtained six weeks postoperatively. Patients were reviewed at six weeks, three months, six months, 12 months and 24 months postoperatively. All patients were primarily kept on in-bed mobilization for six weeks and then gradually progressed to weight-bearing walking over the next six to eight weeks. Demographic factors, operative details, Harris hip scores before the revision and at final follow-up and postoperative thigh pain, if any, were recorded. Postoperative radiographs were studied to determine lysis or loosening. The criteria used for evaluation included the Harris hip scores at final follow-up, as well as overall patient satisfaction (on a visual analog scale model). Results were classified into excellent, good or poor on a simplified assessment scale (taking any improvement from the preoperative highest Harris hip score and minimum 5 points on the VAS satisfaction score as a good result and extrapolating excellent and poor results) as depicted in Tables

**Table 1:** The details of patients analysed

Patient	Age/Sex	1° diagnosis	1° implant	Pre-op score	Duration of Sx	Screws in cup	Blood loss	Complications	Wt bearing
BTV	78/M	AVN	THR	51	1hr 40m	No	450ml	-	5mths
VNJ	55/F	AVN	THR	52	1hr 55m	No	550ml	-	5½mths
SNP	62/M	# NOF	DHS	55	1hr 40m	No	650ml	-	5mths
MLP	56/M	AVN	DHS	32	1hr 25m	No	250ml	-	3mths
KKP	72/F	# IT	DHS	24	1hr 30m	No	350ml	-	4mths
SRT	61/F	# subtroch	DHS	29	1hr 40m	No	450ml	-	5mths
AJG	69/F	RA	THR	41	2hr 25m	Yes	650ml	Shaft #	5½mths
VBP	37/M	AVN	THR	37	1hr 55m	No	750ml	-	5mths
DMP	54/M	# subtroch	DHS	42	1hr 20m	No	250ml	-	4mths

SSP	72/F	# IT	DHS	39	1hr 10m	No	250ml	-	3½mths
NMS	52/F	RA	THR	35	1hr 30m	Yes	450ml	-	5mths
SKR	55/M	# NOF	DHS	32	1hr 20m	No	300ml	-	4mths
JKP	49/M	# IT	DHS	34	1hr 10m	No	400ml	-	3mths
RGK	69/F	OA	THR	32	1hr 40m	No	550ml	-	5mths
RPS	75/M	AVN	DHS	30	1hr 45m	No	650ml	-	5½mths
HMR	54/M	AVN	THR	42	1hr 10m	No	450ml	-	5 mths
AMR	65/M	AVN	THR	34	1hr 25m	No	250ml	-	4mths
RRT	72/F	AVN	THR	26	1hr 20m	No	400ml	-	5mths
MMS	52/F	# NOF	DHS	32	1hr 20m	No	500ml	-	4mths
SKS	56/M	AVN	THR	35	1hr 20m	Yes	650ml	-	3mths
NBS	62/F	# IT	DHS	41	1hr 20m	No	450ml	-	3mths
VMG	42/M	AVN	THR	52	1hr 10m	No	250ml	-	4mths
RBV	50/F	AVN	THR	38	1hr 20m	No	250ml	-	3mths
SPR	66/M	AVN	THR	32	1hr 30m	No	450ml	-	4mths
RNV	58/F	AVN	THR	38	1hr 45m	No	500ml	-	4mths

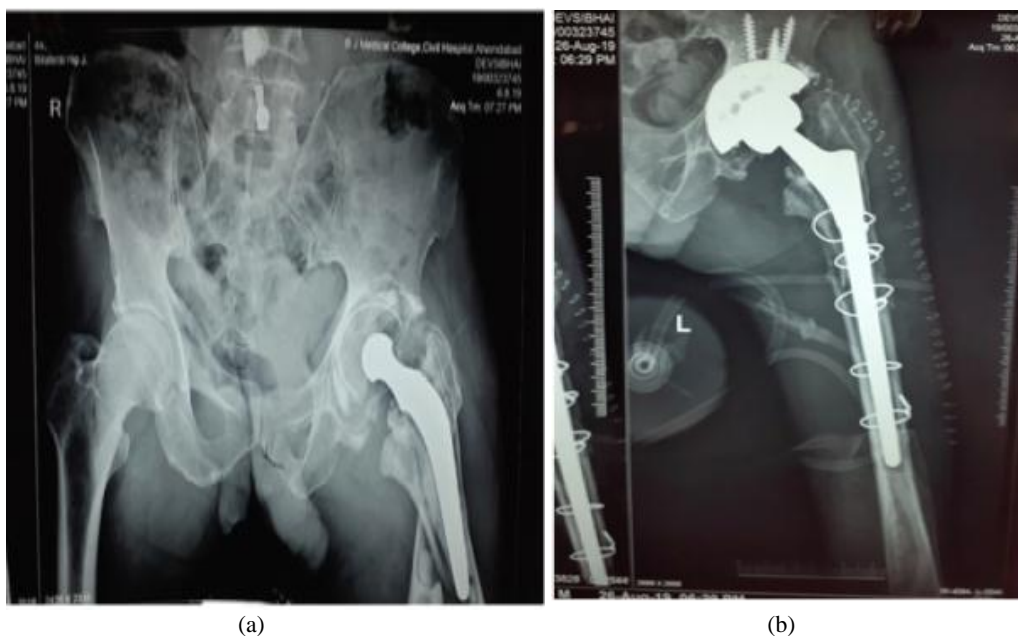
**Table 2:** Criteria for result evaluation and results

Result	Pre-op harris score	Post-op harris score	Patient satisfaction	Patients
Excellent	< 40	> 75	> 7	7
Good	< 40	50-75	5-7	15
Poor	< 40	< 50	< 5	3

**Results**

The Harris Hip scores improved from a preoperative average of 37 (range, 24-51), to a postoperative average of 78 (range, 21-91). Patient satisfaction scores similarly improved from a preoperative average of 5, to a postoperative average of 7. In 8 patients with peri-prosthetic fracture, we resorted to cerclage wiring to hold the fractured fragments. Sixteen patients (ten post-failed DHS and six post THA) proceeded without the need for extensive cerclage wiring. In patients having cemented femoral stem, burr was used to remove cement and, thus helping in removal of cemented stem. One patient had protrusion of acetabular cup and had deficient

acetabular wall for which anti protrusion cup was used. There was no need of osteotomy in the ten cases following DHS removal, however during revision with cementless stems, there is a risk of propagating a fracture from the trochanter down into the shaft. Patients undergone cerclage were put on long knee brace and were immobilised for 6 weeks. There was no limb length discrepancy, measured or felt by any patient following cementless stems. In cases of previous scars, we followed same incision, if standard incision was falling on previous scar or else ignored and proceeded with our independent incision.



**Fig 1:(a)** Preoperative X-Ray (AP view) of the pelvis shows peri-prosthetic fracture in operated cemented total hip arthroplasty (THA). **(b)** Postoperative X-Ray (AP view) of left hip at 11 months of cementless revision stem ('Solution'™) for the failed THA

**Discussion**

Revision hip replacement presents its own unique set of challenges. One of the issues that need to be addressed includes the method of femoral stem fixation (cemented or cementless). Amongst the cementless group, further decision needs to be taken as to the extent of coating (proximal, distal

or extensive) and stability (primary press-fit and/or secondary bony ingrowth). The possible complications (fractures, stress shielding, osteolysis, loosening, subsidence and migration) and prognosis also needs to be looked into. The method of choice of fixation of the revised femoral components is controversial. Despite improvements in

cementing techniques, the re-revision rates of cemented femoral components still increase with time and the radiological loosening rates are still high.<sup>7</sup> Other disadvantages cited are extensive bone loss (to accommodate cement) and inadequate primary (inability to achieve proximal stability with deficient femora) or secondary stability (windshield wiper loosening of the cemented stem). Some authors have, however, reported good results when cementation of the femur was used in conjunction with impacted cancellous allografts. This method is however technically demanding and fraught with complications (fracture and early subsidence). Revision surgery in previously operated cemented stem is challenging in terms of removal of stem and associated with complications like fracture, osteolysis etc.

Proximally porous-coated femoral components have not known to consistently produce favorable outcomes. Increased interest in proximally porous coated stems was sparked in the 1980s by first generation cemented stem failures in young patients and concerns arising due to extensively porous coated cementless stems regarding thigh pain and stress shielding. Despite design modifications, the modern proximally coated stem has not eliminated thigh pain or stress shielding. Highly modular designs that afford assembly of a combination of adequately filling metaphyseal and diaphyseal portions may work to achieve the goals of appropriate primary as well as secondary fixation and stability. The intraoperative flexibility provided by choices of diameter, stem length, fixation type and proximal stem size and orientation is purported to enable establishment of a stable hip center. This however, needs to be customized to each revision situation. However, only a few short-to intermediate-term results have been reported. Proximal coating does not protect against loss of bone mineral content proximally or distally in the femur. Decreasing the extent of porous coating alone does not necessarily reduce proximal femoral bone loss.

Isolated distal coated implants have been reported to show extensive proximal stress shielding and osteolysis with trochanteric fractures.

Extensively porous-coated femoral components with distal bone fixation as the primary fixation principle have shown promising results in numerous long-term studies, both clinically and radiographically. The components can achieve secondary stability by distal bone ingrowth where the condition of the host bone is still good, more so when the quality of the proximal bone stock is poor. The Wagner prosthesis has been suggested as an attractive option, because it can restore the proximal bone stock. Subsidence of the component, cost considerations and high rates of dislocation may, however, preclude its more extensive use. The clinical results of a series using an extensively Hydroxyapatite (HA) coated stem were similar to those using an extensively porous-coated stem. So the question of whether an extensively HA-coated implant will be superior to an extensively porous-coated implant with regard to stress shielding remains as yet unanswered.

Stability all along the stem is desirable. Boden *et al.*, demonstrated in their radiological study on periprosthetic bone changes in two different uncemented femoral stems employing different concepts of fixation that, unstable stems eventually led to loss of bone mineral density and eventual loosening along the entire length of the stem, leading to early loss of fixation and failure.

Stressshielding has not shown to produce adverse consequences in extensively porous coated THAs. A long-

term study on the clinical consequences of stress shielding in a series of 223 cementless THAs compared the outcome of 48 THAs that had radiographically evident stress-shielding with 160 THAs that did not have radiographically visible stressshielding or that had less severe stressshielding. Stressshielding was found to be more likely in females, patients with a low cortical index and patients with larger stems. Patients with stressshielding had a lower mean walking score than patients without stressshielding and less osteolysis. No patient with stressshielding, however, had any loosening, implant fractures or loss of porous coating. The revision rate was 13% (six hips) among hips with stressshielding and 21% (33 hips) among hips without stressshielding. Fifteen-year survival was 93% among hips with stressshielding and 77% among hips without stress-shielding. Severe stressshielding correlates with preoperative osteoporosis and larger diameter stems but not necessarily failure.

Persistent thigh pain has been cited as one of the most disabling complications following cementless femoral fixation. Reasons cited by various authors have included stem tip cortical hypertrophy, stress fractures and intermittent impingement (inadequate distal fill). Paprosky *et al.*, reported in their study of 170 patients that after a mean follow-up of 13.2 years, the total mechanical failure rate was only 4.1%. Bone ingrowth was achieved in the majority (83%) of patients. Only one patient experienced considerable thigh pain but this spontaneously subsided with time. The high incidences of thigh pain reported may be related to the larger size of the femoral component used and distal canal impingement that was achieved. Eighty-five per cent of the femoral components used had a diameter of 13.5 mm or more in his series. Significant thigh pain in bone ingrown stems has been observed more commonly in osteoporotic femurs and bone stock deficient femurs.

Intraoperative fractures have been reported by many authors with different implant designs and approaches. Caution needs to be exercised when inserting a long, straight, extensively coated femoral component. Paprosky *et al.*, reported intraoperative fractures during stem insertion in 8.8% of patients in their series; however, the predisposing factors to this complication were not mentioned. In our study, there were three intraoperative controlled fractures and one distal extension with perforation. We tried to correlate our cases with diaphyseal perforation and distal extension of the fracture with the use of a straight non-anatomic long and thick femoral stem. A radiographic study found that significant anterior cortical thinning was more common in Chinese patients if 200-mm straight stems were used, attributed to the more pronounced anteroposterior bowing of femora in the Chinese population. We have used the bowed 200-mm femoral components and although our experience is very limited, they have shown to help minimize the risk of anterior cortical erosion or distal perforation.

The use of a strut allograft in conjunction with an extended trochanteric osteotomy in patients with poor proximal femoral bone stock decreases the stresses on the stem by 48% and has been recommended by Busch *et al.*, in their analysis of fractures in distally fixed femoral stems.

Our series has a short follow-up to really determine the true efficacy of this cementless system in the long term, especially with regards to proximal stress shielding and osteolysis. However, all but one patient had considerable improvements in their hip scores and were very uniformly satisfied with the procedure at last follow-up. Traditionally, long-stem cemented femoral stems were used to tackle the problem of

proximal bone deficiency with uniformly poor results. We may be premature in concluding that the extensively coated revision femoral stem works wonderfully in bypassing proximal femoral deficient femora, but in the short term, our patients have shown results comparable to results following cementless hip revisions in other centers worldwide. The possibility of secondary stress shielding leading to proximal osteolysis also seems remote theoretically (as secondary bone ingrowth has been shown) with extensive coating.

### Conclusions

The extensively coated cementless ('*Solution*') femoral stem may provide a reasonable 'solution' to this extremely challenging revision total hip replacement. The proximal femoral deficiencies can be relatively easily bypassed and distal fixation achieved with this porous-coated stem. However, extreme care needs to be taken to avoid fractures and penetration of the femoral shaft (which can occur if a straight stem is inserted without understanding the natural bowing of the femoral shaft). Peri implant fractures can be managed to a great extent by cerclage wiring.

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