

Original research

Cementation of a monoblock dual mobility bearing in a newly implanted porous revision acetabular component in patients undergoing revision total hip arthroplasty

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ABSTRACT

Background: The most common indications for revision total hip arthroplasty are instability/dislocation and mechanical loosening. Efforts to address this have included the use of dual mobility (DM) articulations. The aim of this study is to report on the use of cemented DM cups in complex acetabular revision total hip arthroplasty cases with a high risk of recurrent instability.

Methods: A multicenter, retrospective study was conducted. Patients who received a novel acetabular construct consisting of a monoblock DM cup cemented into a fully porous metal shell were included. Outcome data included 90-day complications and readmissions, revision for any reason, and Harris Hip Scores.

Results: Thirty-eight hips in 38 patients were included for this study. At a median follow-up of 215.5 days (range 6–783), the Harris Hip Score improved from a mean of 50 ± 12.2 to 78 ± 11.2 ($P < .001$). One (2.6%) patient experienced a dislocation on postoperative day 1, and was closed reduced with no further complications. There was 1 (2.6%) reoperation for periprosthetic joint infection treated with a 2-stage exchange.

Conclusions: In this complex series of patients, cementation of a monoblock DM cup into a newly implanted fully porous revision shell reliably provided solid fixation with a low risk of dislocation at short-term follow-up. Although longer term follow-up is needed, utilization of this novel construct should be considered in patients at high risk for instability.

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Introduction

Revision total hip arthroplasty (rTHA) is a technically challenging surgery with a high risk of complications. Currently, the most common indication for rTHA and re-revision THA is

instability/dislocation, which has been reported to range from 6.6% to as high as 28% of all rTHA patients [1–11]. Management options include the use of large femoral heads, constrained acetabular liners, and dual mobility (DM) articulations. Utilization of a larger femoral head confers stability by increasing the head-to-neck ratio, range of motion (ROM) prior to impingement, and head-jump distance [12]. However, the effects can become diminished with acetabular defects that result in cup placements which deviate from the ideal hip center of rotation [13]. Additionally, larger femoral heads have been associated with increased volumetric wear even with the presence of highly cross-linked polyethylene liners [14]. Finally, because these larger femoral heads may require the use of a thinner liner, there remains the potential for polyethylene fracture and mechanical failure in some cases [15].

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Meanwhile, constrained acetabular liners are designed to lock the femoral head into the inner bearing surface, which leads to higher forces on the acetabular cup. Consequently, constrained liners restrict ROM causing prosthetic impingement that can lead to unacceptably high failure rates [16,17], including early catastrophic failures in freshly implanted revision cups. To address some of these shortcomings, DM bearings have been advocated.

DM articulations feature an unconstrained tripolar design with 2 mobile articulations. The first articulation is between the prosthetic head and the inner surface of the polyethylene outer head, and the second is between the outer surface of the polyethylene head and the monoblock metal acetabular shell or metal acetabular liner. At the extremes of ROM, the stem engages the edge of the polyethylene liner, causing it to articulate with the inner surface of the metal acetabular shell. This design affords the patient a greater impingement-free ROM while enlarging the effective size of the femoral head, conferring the mechanical advantages offered by a larger femoral head-jump distance. The current generation of DM implants has shown remarkably low dislocation rates following primary THA and rTHA [18–26]. A recent meta-analysis by Levin et al. [27] reported a short- to mid-term dislocation rate of 2.2% following rTHA with the use of DM articulations. Early concerns over excessive early wear due to the additional bearing, aseptic loosening, and intraprostatic dislocation (IPD) have been largely alleviated, with an aseptic survivorship rate of 97.7% and aseptic loosening and IPD rates at 0.3% and 0.7%, respectively [27].

Although biomechanical studies have validated the use of cementation of a DM cup into a well-fixed metal acetabular shell as a viable alternative to a standard cemented polyethylene liner, clinical reports evaluating outcomes of this construct in patients at high risk for recurrent instability and dislocation have been equivocal [22,28–31]. The goal of this study is to analyze the short-term outcomes, and rates of complications, reoperations, and re-revisions of a DM cup meant for cementation cemented into a newly implanted highly porous revision acetabular shell. Our hypothesis is that this reconstruction construct would decrease the incidence of instability after complex rTHA, without an increase in early construct failure.

Material and methods

A multi-institutional retrospective study was conducted using clinical data of patients who received a novel rTHA construct that utilized a monoblock DM cup that is intended for insertion with cement (cemented POLARCUP; Smith & Nephew, Memphis, TN), cemented into a fully porous revision acetabular component (REDAPT; Smith & Nephew). Two institutions contributed the data of 34 patients and 4 patients, respectively, to this study. The study procedures were reviewed and approved by the university Institutional Review Board (Study #i17-00535).

Data collection

All institutions participating in this study performed a retrospective chart review of a consecutive cohort of patients who underwent rTHA surgery and received the rTHA construct. Baseline demographics (age, gender, race, and insurance type), preoperative status (body mass index, and Charlson Comorbidity Index, radiographic Paprosky classification of the acetabular defects, number of previous revision surgeries, time interval from last hip arthroplasty, surgical indication), surgical factors (extended trochanteric osteotomy performed, allograft used, number of screws used, concomitant acetabular cage usage, intraoperative complications), and quality outcomes (length of stay, inpatient complications, 30-day and 90-day readmissions, all-cause re-revisions) were collected.

Patients

Thirty-eight patients treated by 7 fellowship-trained arthroplasty surgeons between May 2016 and June 2018 were included. All patients who received the POLARCUP cemented into a REDAPT acetabular component over this time period were included in this study. No patients were excluded. The decision was made to use this construct if it was felt by the operating surgeon that the patient would be at a high risk of instability following a complex acetabular reconstruction in which a fully porous acetabular shell was used. Risk was defined by the degree of acetabular bone loss (as defined by the Paprosky classification), as well as the patient history and indication for revision [32].

The mean patient age was 62.7 ± 9.7 years. There were 18 males (47.4%) and 20 females (52.6%) with a mean body mass index of 29.7 ± 7.0 kg/m². Patients underwent a mean of 1.6 prior reconstructive hip surgeries (range 1–4), including the primary THA. The mean amount of time between the primary THA and the revision surgery of interest was 12.7 ± 9.2 years. Preoperatively, the majority of patients ambulated with either a rolling walker (13, 34.2%) or cane (16, 42.1%). According to the Paprosky classification, 4 (10.5%) patients were type IIA, 10 (26.3%) patients were type IIB, 6 (15.8%) patients were type IIC, 9 (23.7%) patients were type IIIB, and 9 (23.7%) patients were type IIIB [32]. Additional demographics can be found in Table 1. Specific indications for rTHA included 23 (60.5%) patients for aseptic loosening of the acetabulum, 9 (23.7%) for periprosthetic joint infection, 4 (10.5%) for instability, and 2 (5.3%) for malorientation of the acetabular cup and soft tissue impingement (Table 2).

Surgical technique

Twenty-seven (71.1%) cases were performed using a posterior approach and 11 cases (28.9%) were performed using a modified direct lateral approach. Femoral stems were revised in addition to the acetabular components in 20 (52.6%) cases. Extended trochanteric osteotomies were performed to extract well-fixed femoral components in 7 (20%) cases. Fresh frozen cancellous allograft was used to fill contained defects in 18 (47.4%) cases, and concomitant acetabular cages were used in 11 (28.9%) cases. Mean surgical time was 208.6 ± 62.9 minutes.

The revision shell is unique, offering a combination of locking and nonlocking cancellous bone screws. Following final cup insertion, the DM monoblock acetabular cup was then cemented in place, when the cement had reached a doughy consistency (Fig. 1). The metal acetabular cup intended for cementation is manufactured from stainless steel. Its backside design features antirotation fins as well as 0.35-mm equatorial teeth that further enhance primary stability. The monoblock DM shell was a minimum of 11 mm smaller in outer diameter than the revision shell utilized. The median porous metal shell size was 60 mm (range 54–76), the median polyethylene outer head size was 47 mm (range 43–63), and the inner femoral head sizes were 28 mm (in cups ≥ 47 mm) and 22 mm (43 and 45 mm cups), respectively. An example of preoperative/postoperative pelvic radiographs is shown in Figure 2.

Results

Thirty-eight patients were available for both clinical and radiographic evaluation at a median follow-up of 215.5 days (range 6–783). There were no intraoperative complications. There were 7 (18.4%) inpatient complications. Two (5.3%) were surgical complications and included an anterior hip dislocation on postoperative day 1 in 1 patient and proximal deep vein thrombosis in another patient. The dislocation was spontaneous and not precipitated by any trauma/falls, and a closed reduction was performed with no

Table 1
Baseline patient demographics (n = 38).

Age (y)	62.7 ± 9.7
Gender	
Male	18 (47.4%)
Female	20 (52.6%)
BMI	29.7 ± 7.0
Race	
African American (Black)	8 (21.1%)
Asian	1 (2.6%)
White	22 (57.9%)
Other	5 (13.2%)
ASA	
1	0 (0.0%)
2	16 (42.1%)
3	20 (52.6%)
4	2 (5.3%)
Charlson Comorbidity Index	2.8 ± 1.6
Smoking status	
Current smoker	5 (13.2%)
Former smoker	17 (44.7%)
Never smoker	16 (42.1%)
Marital status	
Married	11 (28.9%)
Divorced	3 (7.9%)
Single	15 (39.5%)
Other	9 (23.7%)
Insurance type	
Commercial	12 (31.6%)
Medicare	16 (42.1%)
Medicaid	8 (21.1%)
Worker's compensation	2 (5.3%)
Laterality	
Left	17 (44.7%)
Right	21 (55.3%)
Previous reconstructive surgeries	1.6 ± 0.8
Paprosky classification	
IIA	4 (10.5%)
IIB	10 (26.3%)
IIC	6 (15.8%)
IIIA	9 (23.7%)
IIIB	9 (23.7%)
Preoperative ambulatory status	
Rolling walker	13 (34.2%)
Cane	16 (42.1%)
Crutches	2 (5.3%)
Unassisted	5 (13.2%)
Unknown	2 (5.3%)
Mean time from primary to revision (y)	12.7 ± 9.2

ASA, American Society of Anesthesiologists; BMI, body mass index.

complications. At latest follow-up, the patient was doing well with 5/5 abductor strength and had no hip instability since the dislocation. The deep vein thrombosis was treated with heparin and inferior vena cava filter placement; heparin was stopped and the patient resumed aspirin therapy for prophylaxis prior to discharge, with no further complications. Five (13.2%) were medical complications and included supraventricular tachycardia, atrial fibrillation, urinary retention, urinary tract infection, and myocardial infarction in 1 patient each. Four (11.8%) patients had postoperative anemia treated with blood transfusion. Additional surgical information can be found in [Table 3](#).

The majority of patients were discharged home with health services (26, 68.4%), followed by skilled nursing facilities (9, 23.7%), acute rehabilitation facilities (1, 2.6%), and home with self-care (2,

5.3%). Postoperatively, 4 (10.5%) patients experienced complications—3 (7.9%) within 30 days and 1 (2.6%) within 90 days following discharge. One patient experienced a nondisplaced fracture of the greater trochanter, which was treated non-operatively. Two patients experienced infection—1 was treated with an irrigation and debridement due to continued wound drainage, with no further returns to the operating room; the other underwent a 2-stage exchange for a periprosthetic joint infection 10 months after the index revision surgery. One patient was admitted for dehydration and acute renal failure; this patient expired due to cardiac complications and so had an orthopedic follow-up time of only 6 days.

The mean Harris Hip Score at last follow-up was 78 (range 49–95), significantly improved from the mean preoperative score of 50 (range 35–78) ($P < .001$). At latest radiographic follow-up, there were no dissociations at the DM-cement interface. All outcome information is summarized in [Table 4](#).

Discussion

Recurrent instability is the most common cause of failure requiring repeat revision following rTHA. A number of surgical treatment modalities have been proposed to decrease the incidence of hip instability in high-risk patients, including the use of DM bearings [16]. The unconstrained tripolar design of the DM implant enhances stability by effectively increasing the femoral head size while increasing the ROM to impingement and jump distance needed for dislocation. The long-term survivorship as well as rates of dislocation following rTHA with DM has been excellent [27,33]. However, a fraction of high-risk patients will continue to experience dislocation despite these enhanced implant designs. In these patients, novel constructs may be of unique benefit. In this report, we describe a low risk of dislocation among a complex cohort of patients where a novel construct was utilized, including the use of a monoblock DM cup specifically intended for insertion with cement, cemented into a cementless revision acetabular component. Although biomechanical studies have suggested that this type of construct is sound and, in fact, stronger than cemented polyethylene liners which have been commonly used in clinical practice, there have been little clinical data to support the use of this construct [28,34,35].

In many rTHA cases, a well-fixed acetabular shell can be retained; however, all of the cases included in the present study required an acetabular shell revision. Due to the extent of the bone loss and bony defects, it was felt by the operating surgeons that a fully porous revision shell rather than a modular acetabular cup was needed to achieve adequate fixation and reconstruction of the acetabulum. The advantage of using a newly implanted fully porous shell, aside from the location and number of screw holes and shell porosity, is having the ability to place the acetabular shell in the best reconstruction position possible. However, as this may not be the best position for hip stability, a liner is cemented within the shell in a better “safe-zone” position. The use of cement is necessary as these shells have no locking mechanism. In order to impart greater stability to the construct, the decision was made to use a DM shell rather than a polyethylene liner in these cases. An example of this is shown in [Figure 3](#); the revision shell is placed in over 55° of abduction and in a more neutral version in order to achieve good construct fixation, and the DM cup is placed in a more stable fixation around 40° of abduction and 15° of anteversion.

To our knowledge, this is the largest US study to date reporting on the clinical outcomes of a cemented DM cup in a newly implanted fully porous acetabular shell. Our results show that cementation of a DM cup designed for cemented use into a newly implanted highly porous, revision acetabular shell can lead to

Table 2
Indication for revision THA of interest (n = 38).

Aseptic loosening	23 (60.5%)
Septic failure	9 (23.7%)
Instability	4 (10.5%)
Malorientation of the acetabular cup	2 (5.3%)

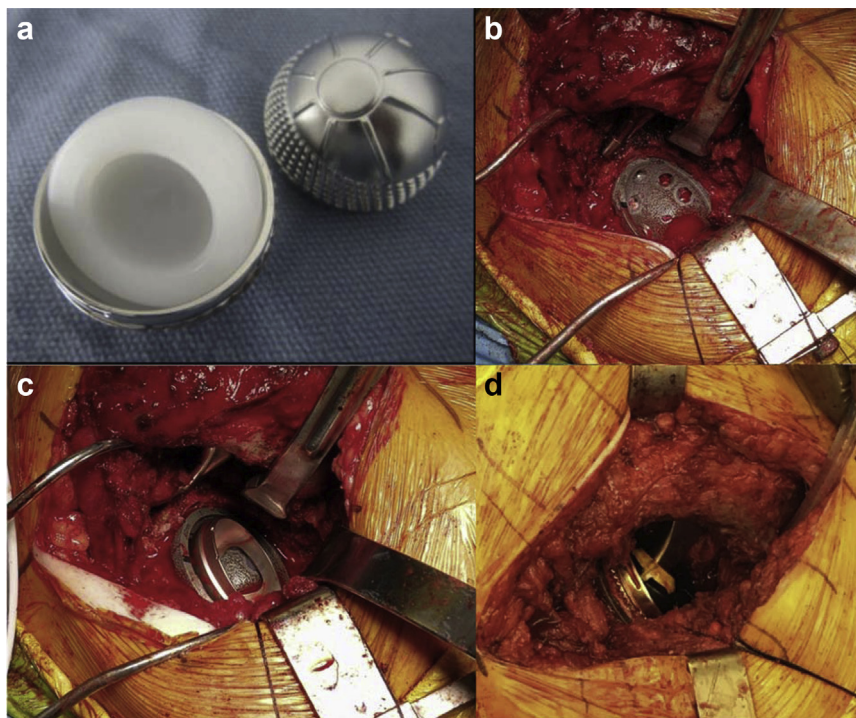


Figure 1. (a) POLARCUP intended for cementation prior to implantation. (b) REDAPT fully porous shell impacted in place following acetabular preparation. (c) Trial placement of DM monoblock cup. (d) DM cup cemented into revision acetabular shell.

enhanced hip stability in the early postoperative period with a low risk of early dislocation or mechanical failure. One (2.6%) patient experienced a spontaneous dislocation on postoperative day 1, which was closed reduced later that day with no further recurrence of instability. In our cohort, there were no IPDs or failures at the DM-cement interface, nor were there any instances of re-revision for early aseptic loosening. Only 1 (2.6%) patient required a re-revision with removal of hardware, which was due to a

periprosthetic joint infection. However, at the time of explant, all the components were noted to be well-fixed. Evidence of functional improvements in this cohort was demonstrated by significant improvements in hip ROM, as well as a significant improvement in Harris Hip Scores.

Studies on the clinical performance of cemented DM cups have been generally limited, but have been more common in Europe where the use of DM is more widespread. Hamadouche et al [36]



Figure 2. Preoperative (left) and postoperative (right) anteroposterior hip radiographs.

Table 3
Surgical information (n = 38).

Anesthesia type	
General	30 (68.4%)
Regional (spinal/epidural)	8 (21.1%)
Surgeon	
Surgeon 1	1 (2.6%)
Surgeon 2	1 (2.6%)
Surgeon 3	11 (28.9%)
Surgeon 4	14 (36.8%)
Surgeon 5	2 (5.3%)
Surgeon 6	5 (13.2%)
Surgical time (min)	208.6 ± 62.9
Median porous metal shell size (mm)	62 (54–76)
Median number of screws	5 (3–14)
Median dual-mobility outer cup size (mm)	48 (43–63)
Median femoral head size (mm)	28 (22–28)
Femoral stem revised	20 (52.6%)
Bone allograft used	
Yes	18 (47.4%)
No	18 (47.4%)
Unknown	2 (5.3%)
Extended trochanteric osteotomy	
Yes	7 (18.4%)
No	31 (81.6%)
Acetabular cage construct used	
Yes	11 (28.9%)
No	27 (71.1%)
Intraoperative complications	0 (0.0%)
Inpatient complications	7 (18.4%)
Medical	5 (13.2%)
Patient 5: supraventricular tachycardia	
Patient 22: UTI	
Patient 28: atrial fibrillation	
Patient 34: urinary retention	
Patient 36: myocardial infarction	
Surgical	2 (5.3%)
Patient 13: DVT	
Patient 37: anterior hip dislocation on POD1	
Postoperative anemia requiring blood transfusion	4 (10.5%)
Length of stay (d)	4.7 ± 2.9

DVT, deep vein thrombosis; POD, postoperative day; UTI, urinary tract infection.

reviewed 47 patients treated with cemented DM cups for recurrent dislocation following primary or revision THA. After a minimum follow-up of 2 years, 2 patients (4.3%) had further episodes of dislocation, which occurred between the polyethylene outer head and the metal shell in 1 hip, and the femoral inner head and the outer polyethylene head (IPD) in the other. The authors suspected that improper placement of the acetabular shell in excessive abduction was responsible for the former, and wear and fatigue deformation due to excessive activity was responsible for the latter. A later follow-up study reporting on the 5- to 13-year results of this cohort was performed [37]. Three patients (5.6%) experienced recurrent dislocation, 2 of which were intraprosthetic. The cumulative survival rate at 10 years was 86.1% using redislocation as the end point, and the authors concluded that DM represents the best reconstructive option for the treatment of recurrent hip instability after THA. Schneider et al explored the outcomes of 96 rTHAs with cemented DM constructs intended for cement use (Novae Stick; SERF, Décines, France) and acetabular cages. Despite the majority of patients having severe acetabular bone loss, they found a high dislocation rate of 10.4% and an aseptic survivorship rate of 99.3% at

8 years [29]. Haen et al [38] found that when there is a moderate deficiency in bone stock, rates of mechanical loosening are comparable regardless of whether an acetabular reinforcement device is used in conjunction with a cemented DM cup.

Plummer et al [22] were the first US group to report on the clinical performance of a construct that was similar to the one used in this series. Nine of the 36 revised hips in their series received DM components cemented into well-fixed or new acetabular shells. Of these, 2 required re-revision due to failure at the DM-cement interface within the first 90 postoperative days. Importantly, these cases utilized a technique that involved roughening the backside of a modular DM liner (modular dual mobility; Stryker, Mahwah, NJ) with a high-speed burr and then cementing it into a shell [22]. The authors, currently, strongly recommend against the use of this technique. At a minimum follow-up of 2 years, no failures had been observed with the other cemented DM cups in their study. Chalmers et al [30] reviewed the results of 18 patients who had undergone rTHA with a monoblock DM construct cemented into a well-fixed or new acetabular component. At mean follow-up of 3 years, 3 patients (17%) experienced postoperative dislocations, and no cups failed at the DM-cement interface. The dislocations occurred at a mean of 4 months postoperatively. Two were treated with open reduction and 1 with revision to a cemented constrained liner. Evangelista et al [31] assessed the outcomes of 18 patients who underwent cementation of a DM monoblock cup, designed for cementation, into a well-fixed or new revision acetabular cup. At a mean follow-up of 36 months, there were no cases of hip dislocation nor any dissociation at the DM-cement interface.

Although DM implants may present a promising solution for preventing hip instability, a potential disadvantage is their increased cost relative to traditional THA implants [39–41].

Table 4
Outcomes (n = 38).

Median follow-up (d)	215.5 (range 6–783)	
Discharge disposition		
Home or self-care	2 (5.3%)	
Home with health services	26 (68.4%)	
Skilled nursing facility	9 (23.7%)	
Acute rehabilitation facility	1 (2.6%)	
Inpatient complications	7 (18.4%)	
30-day complications	3 (7.9%)	Patient 11: hip pain, radiograph showed avulsion fracture of the greater trochanter
Readmissions	2 (5.3%)	Patient 32: hip pain/drainage, treated with irrigation and debridement ^a
90-day complications	1 (2.6%)	Patient 36: dehydration and acute renal failure ^a
Readmissions	1 (2.6%)	Patient 24: irrigation and debridement of hip wound ^a
Re-revisions	1 (2.6%)	Patient 28: removal of hardware
Deep infection	1 (2.6%)	
Dislocation	0 (0.0%)	
Aseptic loosening	0 (0.0%)	
Ambulatory status at latest follow-up		
Rolling walker	11 (28.9%)	
Cane	13 (34.2%)	
Crutches	1 (2.6%)	
Unassisted	12 (31.6%)	
Unknown	1 (2.6%)	

^a Resulted in hospital readmission.

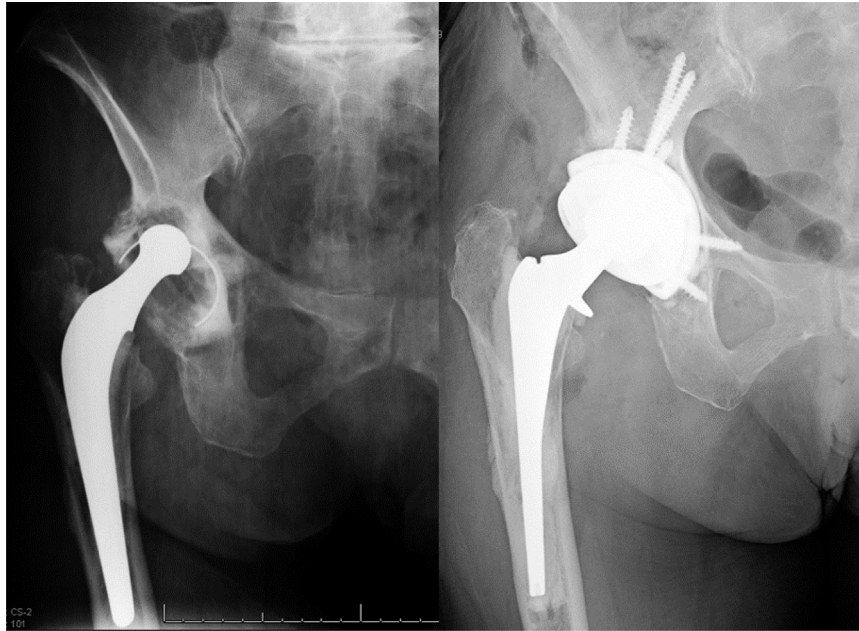


Figure 3. Representative example of a fully porous acetabular shell implanted in a position for maximum bony coverage but less than ideal stability (abduction $>55^\circ$, anteversion $<10^\circ$), with the DM cup cemented within in a better position for hip stability.

However, given the economic burden posed by rTHA procedures, which can exceed \$50,000 in hospital charges alone, the use of DM implants may actually be more cost-effective from a societal perspective, especially in complex rTHA with an increased risk of instability [1].

Our study has several limitations that must be taken into consideration. Only 1 type of fully porous acetabular shell and DM cup was used in this study, and therefore the results may not be generalizable to other designs and constructs. The cohort of patients in this study was relatively small and the follow-up time was limited. Despite this, the incidence rates of dislocation in both primary and revision THA are highest in the immediate postoperative period and remain elevated throughout the first 3 postoperative months, which is adequately covered in the present study [42]. Still, further follow-up will be required to ensure long-term durability of this construct. Future studies may be needed to directly compare outcomes among cemented DM cups, constrained liners, and large femoral heads utilized in complex THA revision cases.

Conclusions

Cementation of a DM monoblock cup into a newly implanted fully porous revision shell was associated with a low risk of surgical complications and re-revision at short-term follow-up. This technique allows for placement of the porous cup such that bony purchase is maximized, and allows for improved placement of the DM cup with regards to abduction, and anteversion, and the hip's natural center of rotation. Considerations for this construct should be made in patients at high risk of dislocation in order to provide durable fixation and improved stability.

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