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Primary Hip

Direct Cementation of Dual Mobility Cups Into the Bony Acetabulum in Primary Total Hip Arthroplasty: Clinical and Radiographic Outcomes at a Minimum 5-Year Follow-Up

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Background: Cemented dual mobility cups (DMCs) are commonly used in combination with acetabular reinforcement devices. Indeed, according to literature, direct cementation of metal-backed acetabular components into the bony acetabulum remains controversial as this technique is potentially associated with increased rates of aseptic loosening. Therefore, this study aimed to evaluate the clinical and radiographic outcomes of DMC cemented into the bony acetabulum in primary total hip arthroplasty (THA).

Methods: A total of 49 THA (48 patients, mean age 78 years [range, 51 to 91]) performed with direct cementation of a DMC into the bony acetabulum were prospectively included in our total joint registry and retrospectively reviewed. The clinical outcome was assessed using the Harris hip score (HHS). The radiographic outcome included measurement of component positioning and occurrence and progression of demarcation around the cemented DMC. Complications were reported with a particular attention to cemented fixation failure and aseptic loosening.

Results: At a 7-year mean follow-up (range, 5 to 8), the pre-to postoperative HHS improved from 47 (range, 30 to 58) to 92 points (range, 80 to 98) ($P < .01$). Nonprogressive and focalized demarcations were observed in 7 THA (14%). Importantly, no progressive demarcation or DMC aseptic loosening was observed.

Conclusion: Direct cementation of DMC into the bony acetabulum ensured a stable fixation with no progressive demarcation or aseptic loosening at midterm follow-up. Therefore, this technique can be selectively considered in primary THA, especially in elderly or frail patients to avoid potential mechanical failure of press-fit fixation due to altered bone quality or additional morbidity related to the use of acetabular reinforcement devices.

Instability remains a major concern and one of the most common reasons for revision after total hip arthroplasty (THA) [1]. Dual mobility cups (DMCs), which combine large head bearing and low-friction arthroplasty concepts, have been first introduced by Bousquet in France during the late 1970s. Over the past decades, numerous clinical studies have reported low dislocation rates with the use of DMCs that average 0.9% in primary THA, both in patients at risk for dislocation and in nonselected patients [1–7]. Furthermore, with the introduction of highly cross-linked polyethylene for the mobile component, no increase in wear, osteolysis, or aseptic loosening has been reported with modern cementless DMC compared to conventional THA at 10- to 12-year follow-up [6,8–10]. However, achieving a stable press-fit fixation with cementless monoblock DMC could be compromised in patients who have altered bone quality, as no additional screw fixation to enhance the primary stability is allowed by the metal-shell design. This is especially true in elderly or frail patients suffering from osteoporosis; cemented acetabular constructs could be advocated

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rather than mistakenly increasing the reaming diameter for the reason of insufficient primary stability with the trial component. Indeed, this common technical issue could further obliterate bone stock and primary stability of the cup, and/or lead to irritation of the iliopsoas tendon due to insufficiency of the acetabular anterior wall with an oversized cup [11]. Typically, cemented DMC are used in combination with acetabular reinforcement devices such as a Kerboull cross plate, Ganz ring, or Burch-Schneider antiprotrusio cage [12–14]. However, the use of acetabular reinforcement devices in primary THA could lengthen operative time, increase blood loss, cause soft tissue damages to the gluteus muscles, increase the risk of neurovascular injury, and increase the overall cost of the procedure. Consequently, beside the use of modular DMC that are more expensive with potential for fretting corrosion [15,16], the alternative could be the direct cementation of a monoblock DMC into the bony acetabulum. However, concerns remain in regard to this technique. Indeed, several authors abandoned the direct cementation of conventional titanium metal-backed acetabular components in the middle of the 1990's due to increased rates of progressive demarcations, cemented fixation failure, and aseptic loosening with cup migration [17–20].

To date, clinical series reporting outcomes of the direct cementation of a DMC into the bony acetabulum are sparse in literature [21–23]. Therefore, this study aimed to evaluate the clinical and radiological outcomes of DMC cemented into the bony acetabulum in primary THA with a particular attention to occurrence of cemented fixation failure and aseptic loosening.

Patients and Methods

This study was approved by our institutional ethical committee (CER-VD# 2019-00919).

Patient Characteristics

From January 1, 2014 to December 31, 2016, 720 primary THAs with DMC (among 1,180 primary THAs in total) were performed and prospectively included in our institutional total joint registry. After registry review, we identified 49 primary THAs with direct cementation of a DMC into the bony acetabulum performed in 48 patients who had completed a minimum follow-up of 5 years at the time of evaluation. The indication was hip osteoarthritis (OA) in 38 THAs (78%) and femoral neck fracture (FNF) in 11 THAs (22%). The mean follow-up of the series was 7 years (range, 5 to 8).

Baseline patient characteristics are reported in Table 1. All the patients presented with at least one risk factor for instability [24]. The perioperative data including operative times, blood losses, and postoperative complications were collected. The operative time was calculated from skin incision to wound dressing. The blood loss was calculated as fluid accumulation in the suction device after subtracting the irrigation fluid and weighing blood absorbed by gauze swabs. Operative reports were reviewed for assessment of the surgical approaches, techniques of cementation, implants, and intraoperative complications.

Table 1
Baseline Patient Characteristics.

Sex	
Women	37 (77%)
Men	11 (23%)
Age at surgery (mean [range])	78 y (51-91)
Body mass index (mean [range])	26 (17-35)
ASA score	
ASA 1	3 (6%)
ASA 2	16 (33%)
ASA 3	27 (57%)
ASA 4	2 (4%)
Risk factors (RF) for instability[a]	Average per patient = 2.2
	1 RF: 6 (13%)
	2 RF: 27 (56%)
	≥3 RF: 15 (31%)
Indication	
Hip osteoarthritis	38 (78%)
Femoral neck fracture	11 (22%)
Follow-up (mean [range])	7 y (5-8)

ASA, American Society of Anaesthesiologists.
[a] Risk factor for instability: age ≥75 y, prior hip surgery, underlying diagnostic of femoral neck fracture, neuromuscular disease, cognitive dysfunction, alcoholism, and ASA score ≥3 [24].

Surgical Technique and Postoperative Care

All the THA were performed through a direct anterior (10 THA, 24%) or posterolateral approach (39 THA, 76%) by or under the direct supervision of a senior fellowship–trained hip surgeon. A single design of cemented dual mobility cup (Liberty AC, ATF, Marignier, France) was implanted in association with a cementless or cemented Müller-type straight femoral stem. The Liberty AC DMC is a cylindro-spherical metal-shell cast from M30NW stainless steel of 3mm thickness (See Fig. 1). The outer surface of the metal-shell is polished and specifically designed for cementation with concentric circumferential and radial grooves to improve cement interdigitation and lever-out and torsional strength of the cemented fixation (See Fig. 1) [25]. The inner surface of the metal-shell is highly polished to articulate with the polyethylene mobile component constituting the so-called "large articulation" of the dual mobility cup [9,10]. After hip exposure, reaming of the acetabular cavity was performed same-size than the preoperatively planned DMC with 2 millimeters (mm) progressive reamers. The reaming was extended up to the acetabular fossa without preservation of the acetabular subchondral bone plate in order to achieve appropriate positioning of the metal-shell into bleeding trabecular bone for optimal osseointegration. In these 49 THA, the decision to cement the DMC was taken intraoperatively as the primary press-fit stability with the trial component considered as insufficient.

Fig. 1. Illustration of the Liberty AC (ATF, Marignier, France) dual mobility cup. The outer surface of the metal-shell is polished with concentric circumferential and radial grooves to improve cement interdigitation and cemented fixation strength.

Then, in order to keep a 2 mm circumferential thickness of the cement mantle around the metal-shell, a definitive DMC sized 2 mm below the last reamer diameter was cemented into the bony acetabulum [25]. Before cementation, the bony acetabular cavity was carefully cleaned with pressurized pulsed irrigation and anchorage holes were performed with a curette to improve cement penetration into the trabecular bone [26]. A single dose of vacuum-mixed bone cement containing gentamicin (Palacos R + G, Heraeus Medical, Wehrheim, Germany) was thickly applied and pressurized into the acetabular cavity using a dedicated pressurizer. Then, the cemented DMC was placed using manual pressure seeking a cup anteversion and abduction angles of 15 ± 10° and 40 ± 10° respectively, and centralized with a particular attention to ensure a uniform 2 mm circumferential thickness of the cement mantle and to avoid a "bottoming out" of the DMC against the acetabular medial wall [12,25]. The cemented DMC was held in place with a dedicated pusher until cement cured.

Clinical and Radiological Evaluation

The patients returned for postoperative follow-up visits at 2 months, 6 months, 1 year, and yearly thereafter. Medical records were reviewed, including outpatient clinic and hospital reports for readmission. The clinical examination was performed in a standardized manner including the assessment of the Harris hip score (HHS). Plain antero-posterior and cross-table lateral radiographs of the pelvis and affected hip were obtained. The radiographs at 2 months were considered as baseline radiographs for follow-up comparisons. The postoperative radiographs were assessed and measured using the Carestream Vue software (Carestream Health Inc, Rochester, New York) by a fellowship-trained hip surgeon who was not involved in any care of the patients. The DMC abduction angle was measured as the angle between the horizontal line bisecting both acetabular teardrops and the longer diameter of the ellipse made by the metal-shell projection on anteroposterior pelvis radiographs. The DMC anteversion angle was measured as the angle between the metal-shell diameter and the transverse plane on cross-table lateral views of the affected hip. On post-operative radiographs, occurrence and progression of demarcation at the bone-cement interface adjacent to the DMC were evaluated using the classification of Hodgkinson [27], which incorporates the criteria of DeLee and Charnley [28]. The demarcation regardless of its thickness was categorized as type 1 when present in zone 1 of DeLee and Charnley, type 2 when present in zones 1 and 2, type 3 when present in all the 3 zones, and type 4 when the cup had migrated. The thickness in mm and progression of demarcation with time were assessed on serial radiographs. A DMC with progressive circumferential demarcations greater than 2 mm or evidence of cup migration with change in position greater than 5° and/or 3 mm with respect to baseline radiographs was considered as loosened [27,29].

Data Analyses

Descriptive data are presented as means and ranges. Comparison of the pre-to postoperative HHS was performed using a 2-sample *t*-test with a level of evidence set at $P < .05$.

Results

At a mean follow-up of 7 years (range, 5 to 8), the pre-to postoperative HHS improved significantly from 47 (hip OA patients; range, 30 to 58) to 92 points (overall series; range, 80 to 98) ($P < .01$). At the latest follow-up, the mean DMC abduction and anteversion angles were 44° (range, 40 to 52) and 31° (range, 20 to 38), respectively. No DMC migration was observed in comparison to baseline radiographs. In 7 THAs (14%), Hodgkinson's type 1 demarcation with a mean thickness of 1 mm (range, 0.9 to 1.2) was observed on baseline radiographs without any progression at latest follow-up (See Fig. 2). Importantly, these 7 THA remained asymptomatic at latest follow-up.

Regarding the surgical procedures, the mean operative time was 93 min (range, 50 to 140) and the mean blood loss was 350 mL (range, 150 to 1,200). Intraoperatively, one case of femoral fracture of the calcar was reported during final impaction of a cementless stem that was treated with cerclage wiring. Postoperatively, no dislocation was reported. Two cases of Vancouver B1 periprosthetic femoral fractures with cementless stem in place occurred 2.5 and 3 years after THA due to a traumatic fall that were treated with open reduction and internal fixation with plating and cerclage wiring. No THA was revised during the follow-up period.

Discussion

Over the last decades, DMC have demonstrated their effectiveness in the prevention and/or management of instability especially in high-risk patients or when indication to THA is femoral neck fracture [6,30–34]. Along with the introduction of highly cross-linked polyethylene and improvement in implant design, the initial concerns related to wear and intra-prosthetic dislocation reported with the first generation of DMC diminished and the indications for THA with cementless monoblock DMC have been largely widened [34,35]. However, in case of altered bone quality of the acetabulum that could compromise a secure press-fit fixation, the cementation of DMC into a reinforcement device is advocated as no additional screw fixation to enhance primary stability is allowed by the metal-shell design of monoblock DMC. Besides, the alternative could be the direct cementation of a DMC into the bony acetabulum. To our knowledge, clinical series reporting this technique remain sparse with limited to short-term follow-up of 2 to 4 years. Therefore, this study aimed to evaluate the outcome of this technique at a minimum 5-year follow-up. The most important

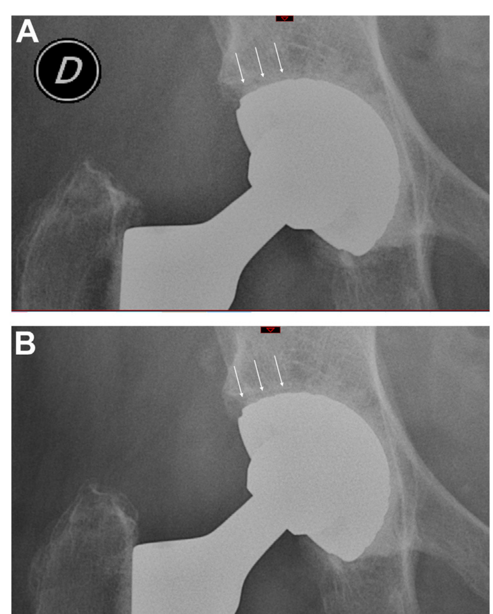

Fig. 2. Anteroposterior pelvis radiograph illustrating a cemented dual mobility cup with focalized demarcation in zone 1 of DeLee and Charnley on baseline radiograph (A) without progression at 6 years of follow-up (B).

finding of this study was that the direct cementation of a DMC into the bony acetabulum ensured a stable fixation in primary THA with no progressive demarcation or aseptic loosening observed at a mean follow-up of 7 years. However, nonprogressive and focalized demarcations were observed in 14% of the THA without clinical consequence at latest follow-up. Our results strengthened those previously reported in the literature [21–23]. To date, 3 clinical series were specifically dedicated to evaluate the outcome of this technique in primary THA [21–23]. In a randomized clinical trial including 60 patients >70 years suffering from hip OA and osteoporosis, Tabori-Jensen et al. [22] compared the fixation of 30 cemented to 30 cementless DMC using radiostereometric analysis (RSA) over a follow-up period of 2 years. Cemented DMC demonstrated no measurable migration from 3 months of follow-up, whereas, cementless DMC had not achieved definitive and complete stability at the final follow-up of 2 years [22]. In addition, the cemented fixation of DMC was less sensitive to low bone mineral density and high cup abduction angle compared to the cementless fixation [22]. In a retrospective series including 105 THA for FNF, Uriarte et al. [23] compared the outcome of 44 cemented to 61 cementless DMC at a mean follow-up of 4 years. Nonprogressive and focalized demarcations were reported in 5% of the cemented DMC [23]. No failure of the cemented fixation with progressive demarcation or aseptic loosening was reported at latest follow-up, whereas, aseptic loosening of a cementless DMC occurred in 1 THA at 3 years [23]. Nevertheless, one intrapelvic migration of a cemented DMC occurred 8 days after THA, and was related to an unrecognized intraoperative acetabular fracture [23]. Similarly, Haen et al [21] reported the outcome of 66 cemented DMC in various indications including revision THA (44%) and primary THA for FNF (26%) and hip OA (30%) at mean follow up of 4 years (range, 1 to 8.2). Demarcations were observed in 5 cemented DMC (12%), being non-progressive and focalized in 2 cemented DMC (5%) [21]. In 3 cemented DMC (7%), demarcations were progressive over the follow-up period, affecting 2 out of the 3 DeLee and Charnley zones with a thickness <2 mm [21]. However, the authors did not mention whether the progressive demarcations around the cemented DMC were observed in primary or revision THA [21]. This represents a limitation to interpret their results as the bony acetabulum during revision THA could present compromised trabecular bone stock for adequate cement penetration and/or structural insufficiency to support securely a DMC without additional screw fixation or reinforcement device [21]. Indeed, the only case of aseptic loosening was reported 3 years after a revision THA associated with acetabular fracture diagnosed intraoperatively [21]. In agreement with the authors, this failure could be attributed to an erroneous indication of the direct cementation of DMC into a fractured bony acetabulum for which the use of a reinforcement device would have been more appropriate [21]. Taken altogether, these results suggest that the direct cementation of a DMC into the bony acetabular ensures a stable fixation in selected patients undergoing primary THA. Particularly, in the current series, this technique was applied when press-fit stability of the trial component was considered inadequate in order to avoid the use of a reinforcement device which impose more extensive soft tissue release than required for a primary THA with potential for neurovascular injury and increased procedural costs. This technique is also an alternative to the routine use of modular DMC especially in elderly and osteopenic patients undergoing primary THA for FNF. Indeed, modular DMC could allow maintaining cementless fixation in patients who have altered bone quality thru additional screw fixation to augment cup stability. However, modular DMC are more expensive than monoblock DMC and are at risk of fretting corrosion at the titanium metal-shell/cobalt-chromium (CoCr) insert interface, CoCr blood ion elevation, and subsequent adverse reaction to metal debris, particularly in the case of malseating of the modular insert [36–39].

With cemented acetabular constructs, the technique of cementation is a major prerequisite for a lasting, stable, and secure fixation [40]. The fixation depends on the cement penetration into trabecular bone, ideally up to 3 to 5 mm, to ensure optimal mechanical stability [40]. In our series, as the DMC were cemented for the reason of insufficient stability with the trial component to allow press-fit fixation, the acetabulum was reamed up to the planed DMC size without preservation of the subchondral bone plate that is poorly permeable to bone cement penetration, particularly when subchondral bone is sclerotic such as observed in hip OA [40–42]. Then, multiple anchorages holes were performed with a curette to increase cement penetration locally and a definitive DMC sized 2 mm below the last reamer diameter was cemented into the bony acetabulum in order to keep a 2 mm circumferential thickness of the cement mantle [25,40–42]. However, the upper-lateral portion of the acetabulum represents a critical area, where the most sclerotic bone is located and the trabecular bone the most difficult to expose [40,41]. In this particular area that corresponds to the zone 1 of DeLee and Charnley, the consequence of suboptimal cement penetration to achieve a closed cement/bone interface can be visualized on antero-posterior pelvis radiographs as thin demarcation at the bone/cement interface [27,28]. In our series, all the demarcations were located in the zone 1 of DeLee and Charnley with a mean thickness of 1 mm. The progression of this particular demarcation has been demonstrated to be a risk factor for aseptic loosening within 10 years [27,28]. However, in our series, no progressive demarcation or aseptic loosening was observed over a mean follow-up of 7 years. The primary reason recommending against the cementation of metal-backed acetabular components into the bony acetabulum was related to the increased risk of aseptic loosening with this technique at short-to mid-term follow-up [17–20]. Ritter et al. [18] reported a survival rate at 10 years of 60% for cemented metal-back acetabular components compared to 90% for cemented all-polyethylene sockets. Similarly, Peraldi et al. [17] reported 26% of progressive circumferential demarcations around cemented metal-back acetabular components with 2% of aseptic loosening at a mean follow-up of 21 months. In addition, Chen et al. [20] reported the 10-year follow-up outcomes of cemented metal-back acetabular components with failure rate due to acetabular loosening up to 41% and a 12-year survivorship of 88%. More recently, in the early 2000s, Mohan et al. [19] reported a survivorship of only 42% at 10 years with cemented metal-back acetabular components. Importantly, in all of these 4 series, the cemented metal-back were made of titanium alloy [17–20]. Although favorable for cementless fixation, the low modulus of elasticity of titanium alloy might be detrimental for cemented fixation with excessive shear stress at the cement/implant interface leading to micromotion and aseptic loosening, such as observed with titanium alloy cemented stems [43]. Cemented monoblock DMC are made of stainless steel or CoCr alloy that is probably a preferable material to be cemented into the bone. However, to our knowledge, no study in literature was designed to evaluate the mechanical properties of cemented fixation of metal-shells into the bone according to their cast material. Also, another potential explanation for the improved cemented fixation obtained with cemented DMC compared to titanium metal-back acetabular components could be related to their different biomechanical behavior. Several biomechanical and retrieval studies demonstrated that motion within DMC bearing surfaces occurs predominantly at the small articulation with the large polyethylene head being completely unconstrained at the large articulation [4,9,44]. This might be favorable in terms of reducing shear stress at the cement/DMC metal-shell interface and explain the difference in results between cemented DMC and conventional metal-back acetabular components [4,9,44].

This study presented with some limitations. It was retrospective without comparison group as the decision to cement the DMC was taken intraoperatively by the senior surgeon according to its appreciation of insufficient press-fit stability with the trial component to allow cementless fixation. Also, the sample size of patients who reached a minimum follow-up of 5 years was limited as this technique was used with caution initially in low-functional demand and frail patients. However, this series is one of the largest dedicated to report outcomes of this technique in primary THA with all the patients who underwent both clinical and radiological examinations at the time of the evaluation. In addition, previous studies demonstrated that demarcations emerging around cemented acetabular components during the first post-operative year are a risk factor for aseptic loosening within 10 years [18,27,40]. Therefore, the mean follow-up of 7 years might be not long enough to allow interpretations over the survivorship in the long term of DMC cemented into the bony acetabulum. Nevertheless, the fact that no demarcation progression was observed at latest follow-up on serial standardized radiographic evaluation might be considered as favorable in the long term (past 8 years).

Conclusion

The direct cementation of a DMC into the bony acetabulum ensured a stable fixation with no progressive demarcation or aseptic loosening at a mean follow-up of 7 years (range, 5 to 8). Therefore, this technique could be selectively considered in primary THA, especially in elderly patients for whom altered bone quality could make the use of a cementless monoblock DMC at risk of early fixation failure. However, non-progressive and focalized demarcations were observed in 14% of the THA. Therefore, longer follow-up is still necessary to confirm cemented DMC survivorship over the long term and outweigh the risks and benefits of this particular technique.

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