Outcomes of Augmented Dual Mobility Acetabular Cups

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Total hip arthroplasty (THA) has become a common operation because of its good functional outcomes and very low risk of complications. Due to improvements in implant longevity, the number of patients with THA implants is growing yearly. Advances in fixation and biomaterial integration have allowed us to expand the indications for primary THA, especially in more challenging cases with acetabular bone loss. However, in parallel with the greater number of THA procedures, the incidence of revisions due to trauma and wear has also increased. In cases of THA revision, acetabular bone defects are often present. Whether for primary or revision THA, the implantation of a cementless cup in patients with an acetabular defect is challenging, as we must ensure satisfactory primary implant fixation to avoid acetabular loosening, restore the hip’s center of rotation, and prevent instability in patients with a higher risk of dislocation.

Because of the recent improvements made to THA implants, we now have a wide range of acetabular cups and reconstruction options available when faced with acetabular defects. The optimal treatment depends mainly on the extent of the defect, quantity of bone remaining and likelihood of obtaining solid fixation on the supporting bone.

Current treatment options include acetabular liner exchange, high hip center, oblong cup, trabecular metal cup with augment, bipolar cup, bulk structural graft, cemented cup, uncemented cup including augmented and jumbo cup, acetabular reinforcement device (cage), and trabecular metal cup-cage. In cases of moderate or severe acetabular defects with preserved sphericity, augmented and jumbo cups are popular alternatives as they are technically straightforward to implant. These
implants allow for primary press-fit fixation that can be supplemented by extra fixation elements, while avoiding having to use acetabular reinforcement rings, which can be challenging to revise. Unfortunately, the dislocation rate in revision cases using uncemented cups remains high at 4% to 12%, with a mean of nearly 9%.\(^3\)\(^{-9}\) Dual mobility cups (DMC) leverage McKee’s principle to increase the jump distance and thereby reduce the risk of implant dislocation.\(^1\)\(^{-3}\) Over the past 30 years, the DM concept has proven to be effective in terms of preventing post-operative instability in both primary and revision THA.\(^1\)\(^{-3}\)\(^{-6}\) Recent comparative studies have confirmed that DMC are better than conventional acetabular cups for preventing instability.\(^9\)\(^{-20}\)

To the best of our knowledge, there have been no reports on the clinical and radiological outcomes of augmented DMC. We hypothesized that the use of augmented DMC in patients with acetabular defects would reduce the dislocation rate and lead to satisfactory bone integration in the medium term despite acetabular bone defect. The aim of this study was to evaluate the dislocation rate and survival associated with augmented DMC.

**MATERIALS AND METHODS**

**Study design and patients**

This was a retrospective, continuous, multicenter study. All patients with acetabular defects who received an augmented DMC during either primary or revision THA at two French teaching hospitals (Dijon, Saint-Etienne) between January 2010 and December 2017 were included. The candidates for augmented cup implantation were patients with a moderate (Paprosky 2A, 2B and 2C) or severe acetabular defect with preserved sphericity (stage 3A). Patients who had a severe oblong defect (stage 3A) or pelvic discontinuity (stage 3B) were treated with antiprotrusion cages and cemented DMC, and thus were excluded from our analysis.

**Surgical technique and implants**

In all cases, the augmented cup used was the COPTOS TH® DMC (SERF®, Décines-Chapier, France). This is a third-generation DMC, forged from 316L stainless steel with a dual coating of plasma-sprayed titanium and hydroxyapatite. This augmented DMC combines press-fit and supplemental fixation. The supplemental fixation consisted of an acetabular hook, two superior flanges that can accept one to four iliac screws and two acetabular pegs (Fig. 1). The 22.2 mm- or 28 mm-diameter femoral heads were made of 316L stainless steel or cobalt-chrome. The more rarely used 28 mm heads were only implanted with size 53 or larger cups to ensure that the polyethylene liner was at least 10 mm thick, as recommended by the manufacturer. The femoral stems used were either cementless or cemented, depending on the quality and amount of femoral bone stock. The Moore posterolateral (n=67, 72%) and Hardinge (n=26, 28%) approaches were used.

**Clinical and radiological assessments**

Clinical and radiological assessments were performed postoperatively at 45 days, 3 months, 6 months, 1 year and then every 2 years until the final follow-up (Fig. 2). The patient’s general condition was evaluated using the American Society of Anesthesiologists (ASA) scale.\(^2\)\(^{1}\) The clinical evaluation consisted of the Merle d’Aubigné Postel (MDP) score and Harris Hip score (HHS).\(^2\)\(^{2}\)\(^{2}\) The radiological evaluation was carried out using OSEIRIX® software (Pixmeo, Bernex, Switzerland). The aim was to look for periprosthetic osteolysis based on the DeLee-Charnley topography\(^2\)\(^{4}\) and for signs of loosening, and to determine whether the cup inclination had changed from the immediate postoperative period to the final follow-up. Any

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**Figure 1. Augmented DMC (COPTOS TH®, SERF) with and without polyethylene insert.**

**Figure 2. X-rays showing an augmented DMC.**
complications such as dislocation, infection, loosening or periprosthetic fracture were recorded.

Statistical analysis
The statistical analysis was carried out using SPSS Statistics software (version 23, SPSS Inc., Chicago, IL, USA). The significance threshold was set at \( P < 0.05 \). The results are expressed as mean ± standard deviation for quantitative variables and as percentages for qualitative variables. After the data were confirmed to be distributed normally, Student’s t-test was used to compare quantitative variables (change in clinical outcome scores over time).

RESULTS

Population and implants
A total of 93 augmented DMC implanted in 93 patients (48 men and 45 women) were included, with a mean postoperative follow-up of 5.3 ± 2.3 years [0, 10]. At the final follow-up, 7 patients (7%) had died from causes unrelated to the THA surgery and 6 patients (6%) were lost to follow-up. The mean age at the time of revision surgery was 73 ± 13 years [27, 94]. The mean BMI was 26.4 ± 5.4 [18, 41]. The distribution of the ASA score was ASA 1 (n = 9, 10%), ASA 2 (n = 46, 49%) and ASA 3 (n = 38, 41%). The indications for THA surgery are listed in Table I. Preoperatively, acetabular defects were graded as Paprosky 2A in 46% (n = 43), 2B in 32% (n = 30), 2C in 15% (n = 14) and 3A in 6% (n = 6). Seventy-four patients (80%) received an acetabular bone graft. These grafts were either an allograft (n = 30, 41%), autograft (n = 29, 39%) or a combination of both (n = 15, 20%). The mean cup diameter was 57 ± 4.8 mm [43, 67]. Iliac screws were used to supplement the press-fit in all patients: 4 screws (n = 54, 58%), 3 screws (n = 28, 31%), 2 screws (n = 10, 11%) and 1 screw (n = 1, 1%). A 22.2 mm-diameter head was used in the vast majority of cases (n = 87, 94%). On the femoral side, a cementless stem was used in 91% (n = 85) of cases and a cemented stem was used in 9% (n = 8).

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>n</th>
<th>Mean FU (years)</th>
<th>Dislocation rate</th>
<th>Cup survival rate (all-cause)</th>
<th>Cup survival rate (aseptic loosening)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jasty et al. 4</td>
<td>1998</td>
<td>19</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>95%</td>
</tr>
<tr>
<td>Patel et al. 5</td>
<td>2003</td>
<td>43</td>
<td>10</td>
<td>5%</td>
<td>92% (14 years)</td>
<td>95%</td>
</tr>
<tr>
<td>Fan et al. 6</td>
<td>2008</td>
<td>47</td>
<td>5.4</td>
<td>11%</td>
<td>87%</td>
<td>94.5%</td>
</tr>
<tr>
<td>Wedemeyer et al. 7</td>
<td>2008</td>
<td>17</td>
<td>6.8</td>
<td>6%</td>
<td>88%</td>
<td>94%</td>
</tr>
<tr>
<td>Lachiewicz et al. 8</td>
<td>2013</td>
<td>129</td>
<td>8.1</td>
<td>9.3%</td>
<td>93.8% (10 years)</td>
<td>97.3% (10 years)</td>
</tr>
<tr>
<td>Gustke et al. 9</td>
<td>2014</td>
<td>196</td>
<td>10</td>
<td>4.2%</td>
<td>98% (4 years)</td>
<td>82.8% (15 years)</td>
</tr>
<tr>
<td>Von Roth et al. 3</td>
<td>2015</td>
<td>89</td>
<td>20</td>
<td>12%</td>
<td>83%</td>
<td>85%</td>
</tr>
<tr>
<td>Our study</td>
<td>2019</td>
<td>93</td>
<td>5.3</td>
<td>3%</td>
<td>94.6%</td>
<td>96.8%</td>
</tr>
</tbody>
</table>

(FU: Follow-up)
Clinical and radiological outcomes

The mean MDP and HHS scores improved significantly between the preoperative assessment and the final follow-up, from 8.7 ± 4.4 [0, 18] to 14.8 ± 3.1 [9, 18] (p < 0.001) and from 42.6 ± 24.4 [2, 100] to 72.2 ± 17.3 [39, 100] (p < 0.001), respectively. A subgroup analysis based on the Paprosky grade found no differences for the MDP and HHS scores (p>0.05). No anterior impingement was reported. The radiological analysis identified asymptomatic and non-progressive osteolysis in 13 patients: 15% (n = 2) in Delley-Charnley zone 1, 13% (n = 2) in zone 2, 39% (n = 5) in zone 3, and 31% (n = 4) in zones 2/3. Of the 93 augmented DMC, 90 were integrated into bone despite the initial acetabular defect and 3 had signs of aseptic loosening. The cup inclination did not change significantly between the immediate postoperative measurement (42.7 ± 8.5° [23, 66]) and the final follow-up (43.5 ± 9.5° [24, 66]) (p = 0.545).

Complications

Four infections occurred. Two were early infections treated by debridement, antibiotics and implant retention; both infections healed and did not recur as of the final follow-up. The other two infections required surgical revision with a change in the implant.

One or more screws broke in five patients. Among them, three had aseptic loosening of the cup that required surgical revision and two had screws break in the first year postoperatively, without aseptic loosening, thus the cup was still in place at the last follow-up.

Three patients suffered a postoperative dislocation; two dislocations were treated by closed reduction and one required open reduction. At the final follow-up, none of these patients reported chronic instability.

Four patients suffered a periprosthetic fracture around the femoral stem. None required the acetabular cup to be changed.

In summary, the acetabular cup was changed in five cases: three due to aseptic loosening (3.2%) and two due to an infection (2.1%). Thus, at the final follow-up, the dislocation rate was 3%, the overall survivorship was 94.6%, and the aseptic loosening rate was 96.8%.

DISCUSSION

This study shows that the use of an augmented DMC in patients with an acetabular defect who are undergoing primary or revision THA gives satisfactory results in terms of the dislocation rate and medium-term osteointegration. Because of their DM bearing, these augmented cups help to limit the occurrence of postoperative implant dislocation in these high-risk patients. Supplemental fixation allows these cementless cups to integrate into bone despite acetabular bone defects.

Numerous studies have shown that the dislocation rate is higher after revision surgery. Guo et al. estimated that the dislocation rate was 9% based on a meta-analysis. The dislocation rate for uncemented cups used in revision cases is reportedly between 4.2% and 12% (Table II), which is higher than the value in our study (3%). While our follow-up was relatively short, given that most dislocations occur in the first few years after surgery, our study provides evidence of the benefit of adding a dual mobility bearing to augmented cups.

While many studies have reported the medium- and long-term outcomes of using uncemented cups including augmented or jumbo cups in the context of THA revision, to our knowledge, there are no published studies on augmented DMC. The addition of a DM bearing does not appear to alter the loosening rate in the short term. Prior short- and medium-term studies have reported survivorship similar to that in our study: 87% at 5 years for Fan et al., 88% at 6.8 years for Wedemeyer et al. and 98% at 4 years for Gustke et al. Over the longer term, Lachiewicz and Soileau reported 79.8% survivorship at 15 years. Gustke et al. reported 96% at 16 years and von Roth et al. reported 83% at 20 years. Since all-case survivorship was 94.6% at 5.3 years in our study, the use of a dual mobility bearing in the augmented cup does not negatively affect implant survival, which remains comparable to that reported in other published studies with a similar follow-up (Table II). Another factor that may influence the survival of revision acetabular cups is the quantity of bone stock remaining. Unfortunately, the literature is not very strong in this area and there is no formal evidence of a causal relationship. In our study, the correlation between the Paprosky stage and cup survival was not determined because there were too few events (cup loosening).

Like Gustke et al., our study mostly captured cases of moderate bone defects (2A and 2B). In our experience, and as explained by Kim’s algorithm for treating acetabular defects, jumbo or augmented cups are recommended mainly for bone defects where some potential exists for biological fixation of a hemispheric cup. This requires a limited bone defect (Paprosky 2A, 2B and 2C) or a more severe defect with a spherical acetabular cavity (3A). This configuration allows for press-fit fixation with biological integration. In this context, the addition of supplemental fixation appears to be relevant, as it augments the primary stability required for the osteointegration of cementless cups. One of the advantages of using augmented cups is that the acetabulum can be prepared by reaming the bone into a larger hemispheric shape. By maximizing the bone contact at the implantation site and reducing the impact of superficial bone defects, which are filled by the cup itself, augmented cups reduce the need for bone grafting. As a result, augmented cups are technically simple to implant. Compared to jumbo cups, supplemental fixation allows good primary fixation with widespread reaming. This avoids the need to medialize the center of rotation of the hip and reduce the bone stock. In cases of severe bone loss, particularly when bone remodeling has resulted in an oblong-shaped cavity, we prefer using an antiprotrusion cage with a DMC cemented inside of it. This type of construct helps to avoid shifting the hip’s center of rotation medially and does not require as much bone graft.

Our study has several limitations. First, it was a retrospective study with a moderate sample size. Nevertheless, our sample size is comparable to those in other published studies on this topic, since the incidence of this surgical indication is low. The mean follow-up in our study was too short to estimate the long-term survivorship of augmented DMC. While we cannot draw any conclusions about late loosening, our study showed that, despite the presence of acetabular defects, these implants can achieve satisfactory osteointegration and combining the DM bearing with an augmented cup does not alter medium-term survivorship.
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CONCLUSION

Use of an augmented DMC, which combines the DM concept with supplemental fixation, helps to reduce the risk of instability and achieves osteointegration despite local bone loss. In patients with an acetalubar bone defect, this cup has satisfactory medium-term outcomes with a low dislocation rate and low surgical revision rate for loosening. We recommend its use in this indication.

AUTHORS’ DISCLOSURES

BB and PM are consultants for SERF (Décines, France). RP, EB and FF receive royalties from SERF (Décines, France).

REFERENCES