Original article

Total hip arthroplasty revision by dual-mobility acetabular cup cemented in a metal reinforcement: A 62 case series at a minimum 5 years' follow-up

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A B S T R A C T

Introduction: Total hip arthroplasty (THA) requires bone reconstruction in case of severe acetabular injury, with risk of dislocation, especially postoperatively. Dual-mobility cups have proved effective in preventing dislocation in THA revision for instability, but their behavior when cemented in a metal reinforcement has been little studied.

Objectives: The present study assessed results for a dual-mobility cup cemented in a metal reinforcement, in terms of aseptic loosening and postoperative instability.

Material and methods: A single-center continuous series of 62 patients receiving such an assembly in THA revision was assessed retrospectively at a minimum 5 years' follow-up. Failure due to aseptic loosening or instability and implant survival at last follow-up were analyzed.

Results: Radiological and clinical analysis was performed at a mean 77 months' follow-up. Mean Merle-d'Aubigné–Postel score was 14, Harris score 73 and Oxford–12 score 23.9 at last follow-up. Complications comprised 5 cases of loosening and 2 of dislocation. Loosening risk was significantly greater in case of < 2 mm cement thickness between cup and reinforcement. Eight-year infection-free survival was 91.9%.

Discussion: The present clinical results were comparable to those in series using the same kind of assembly: the dislocation rate was low, but the rate of aseptic loosening was higher than reported elsewhere. Cement thickness between cup and reinforcement was a determining factor for stability. Cup design may also be relevant to loosening. This technique seemed to be a good option in THA revision with severe bone loss.

Level of evidence: IV, retrospective study.

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1. Introduction

Instability is one of the main complications in total hip arthroplasty (THA) revision, with rates exceeding 20% in some series [1,2]. Dual-mobility acetabular cups showed good results in revision for instability, using cementless impacted models [3–6] or, more recently, cups directly cemented in the bone [7]. In severe acetabular bone loss, bone graft with an acetabular reinforcement is recommended. Wegrzyn et al. [8] validated the mechanical stress resistance of dual-mobility cups cemented into a reinforcement in vitro. Series using this type of assembly [9–13] reported encouraging results, but at short follow-up, with medium-term outcome unclear.

The present study hypothesis was that this type of assembly is effective in preventing dislocation in THA revision, without risk of iterative revision for loosening. We think cementing quality is a determining factor. The main study end-point was dislocation rate, and the secondary criterion was infection-free implant survival at a minimum 5 years' follow-up.

2. Materials and method

A single-centre retrospective continuous series of THA revision using a dual-mobility Quattro® cup (Lépine™) cemented in a metal reinforcement was recruited between January 2005 and January 2011.

The initial series comprised 91 patients (Table 1). Pre- and intraoperative clinical data were collected from patient files. Follow-up had been regular for at least the first 3 years. For

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Table 1
Characteristic of the initial series.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Number or mean ± SD [range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>73 ± 11.9 years [36–93]</td>
</tr>
<tr>
<td>Gender</td>
<td>58 female; 33 male</td>
</tr>
<tr>
<td>ASA score</td>
<td>2.67 ± 0.56 [1–4]</td>
</tr>
<tr>
<td>BMI</td>
<td>27.2 ± 4.67 [19.5–43.7]</td>
</tr>
<tr>
<td>Number of previous revisions</td>
<td>1.8 ± 1.1 [1–7]</td>
</tr>
<tr>
<td>Indications</td>
<td>Aseptic loosening and implant wear n = 60</td>
</tr>
<tr>
<td></td>
<td>Instability n = 16</td>
</tr>
<tr>
<td></td>
<td>Septic loosening n = 15</td>
</tr>
<tr>
<td>SoFCOT grade</td>
<td>Mean: 3.08 ± 0.53 [2–4]</td>
</tr>
<tr>
<td></td>
<td>Stage 2: n = 7</td>
</tr>
<tr>
<td></td>
<td>Stage 3: n = 63</td>
</tr>
<tr>
<td></td>
<td>Stage 4: n = 17</td>
</tr>
<tr>
<td>Uni/bipolar revision</td>
<td>4 reinforcements in place at revision</td>
</tr>
<tr>
<td>Unipolar revision</td>
<td>Unipolar n = 35</td>
</tr>
<tr>
<td>Bipolar revision</td>
<td>Bipolar n = 56</td>
</tr>
</tbody>
</table>

BMI: body-mass index; ASA: American Society of Anesthesiologists; SoFCOT: French society of Orthopedic Surgery and Traumatology.

decesed patients and those lost to follow-up, the absence of any further revision was checked with the community physician.

Six patients were lost to follow-up, but without known failure: 2 had moved house, 3 had become bed-ridden, and 1 declined to participate. Twenty-three patients had died.

First-generation Quattro® cups were used. These have a chromium-cobalt metal-back with high-molecular-weight polyethylene insert, with two circumferential grooves for tightening; they come in 4 sizes: 44, 48, 52 and 56 mm (Fig. 1). The polyethylene insert in the 44 and 48 mm models can take a 22.2 mm metal head, and a 28 mm metal head in the 48, 52, and 56 mm models.

Acetabular bone loss was classified on the SoFCOT system [14]. Surgery used Moore’s posterolateral approach.

Three types of metal reinforcement were used, Burch-Schneider® rings or Link® reinforcements (Fig. 2) in case of pelvic ring rupture or risk of rupture, or otherwise Müller® rings. Bone defects were filled by allograft.

All cups were fixed with Palacos Genta® antibiotic-loaded cement. Cement thickness between reinforcement and cup could

Fig. 1. a: first-generation Quattro® cemented cup as used in the present series; b: new-generation Quattro® cemented cup, with circumferential and transverse grooves.

Fig. 2. Quattro® cemented in (a) a Müller® ring, (b) a Bürch® ring, and (c) a Link® reinforcement.
not be measured directly but was estimated as the difference in internal diameter between reinforcement and cup [15].

Clinical analysis at a minimum 5 years’ follow-up used Merle–d’Aubigné–Postel (MAP), Harris Hip (HHS) and Oxford-12 scores [16].

Last follow-up radiographs were compared versus postoperative views on Imagika™ software. Cup and reinforcement inclination and any implant migration were measured. The margin of error due to manual measurement and difference in pelvic orientation between the two examinations was 5° for implant inclination, and 5 mm for migration. Loosening was screened for as radiolucency at the bone/cement junction [17]. A 10 mm distance between coccyx and pubic symphysis was tolerated, beyond which radiographs were considered imprecise and were not used for assessment of implant migration or change in inclination.

Postoperative complications were collected: dislocations, loosening, infection, pain, and limb-length discrepancy. Failure was defined by revision for instability or aseptic loosening.

Statistical analysis used Xlstar™ software. The following loosening risk factors were assessed: circumstances of revision, cement thickness, number of previous surgical procedures, gender, age, body-mass index, uni- vs. bipolar revision, and type of reinforcement. Infection-free survival was assessed on the Kaplan–Meier method.

3. Results

Finally, 62 patients were assessed, by an independent investigator, at a mean 6.4 years' follow-up (range, 5–9 years).

There were 20 and 42 female patients, with a mean age of 70.5 ± 11.1 years (range, 36–94 years). Mean American Society of Anesthesiologists (ASA) score was 2.5 ± 0.57; mean body-mass index was 27.2 ± 4.8 (range, 19.5–43). Thirty-one cases involved primary revision, 13 second revision, 11 third revision, and 7 fourth or more (Tables 1 and 2).

Etiologies comprised 41 cases of aseptic loosening, 3 of polyethylene insert wear, 7 of instability, and 11 of implant infection (Table 3).

Acetabular lesions comprised 4 stage 2, 45 stage 3, and 9 stage 4. Four patients already had a metal reinforcement, not changed at revision (Table 3).

The femoral stem was also replaced in 34 cases.

Burch–Schneider® rings were used in 8 cases, Link® reinforcements (Fig. 2) in 3, and Müller® rings in 47 (Table 3). Allograft was performed in 58 cases.

3.1. Clinical results

At last follow-up, 25% of the patients could walk without a cane, compared to 9% preoperatively, and 21% walked without limping, compared to 8% preoperatively.

Mean MAP score was 14.4 ± 3.6 (range, 3–18), compared to 11 ± 3 (range, 3–18) preoperatively. Only 12% of patients had disabling pain, compared to 65% preoperatively. Mean Harris score was 73 ± 21 (range, 24–99), compared to 49 ± 16 (range, 17–90) preoperatively.

Mean Oxford-12 score was 23.9 ± 12 (range, 12–52) at last follow-up, mean Devanne score was 2.2 ± 0.8 and Charnley grades were 64.5%, 19.3% B and 16.1% A.

Inferred cement thickness between cup and reinforcement was ≤ 2 mm in 22 cases and > 2 mm in 40, for a mean 3.7 ± 1.5 mm. Table 4 shows cup-reinforcement associations in cases of cement thickness ≤ 2 mm, which comprised 13 bipolar and 9 unipolar revisions.

3.2. Radiology results

Mean cup inclination was 47.16 ± 7.1° (range, 31.6–66.2°). Mean reinforcement inclination was 49.9 ± 7.2° (range, 39.6–69°) immediately postoperatively.

Implant migration and change in cup and reinforcement inclination were analyzed in 37 patients, the others being excluded as the radiographs showed excessive rotation, liable to vitiate the data. There was no significant implant migration at a mean 68.2 ± 5.2 months’ follow-up. There were 2 cases of > 2 mm radiolucency in De Lee zone 1, and 3 in zone 3, all asymptomatic.

3.3. Complications

There were 13 further revision procedures: 5 for aseptic loosening, 1 for recurrent dislocation, and 7 for infection.

Two of the cases of aseptic loosening involved trauma. The first was due to a road accident, 5 months postoperatively (Fig. 3). A new dual-mobility cup was cemented into the original reinforcement.

The second was due to a 2-meter fall, 1 year postoperatively, with acetabular fracture around a Burch® ring (Fig. 4). A new Quattro® cup was cemented in a Link reinforcement.

The other 3 cases of aseptic loosening concerned the cup within the reinforcement, all within the first 15 months. A new cup was cemented into the original reinforcement.

In 1 case of early (1 month) and recurrent dislocation, in an 88-year-old woman, no revision procedure was performed, being contraindicated by the patient’s general health status.

Table 2

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Number or mean ± SD [range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>40 female; 22 male</td>
</tr>
<tr>
<td>Age</td>
<td>70.5 ± 11.1 [36–94]</td>
</tr>
<tr>
<td>BMI</td>
<td>27.2 ± 4.8 [19.5–42.9]</td>
</tr>
<tr>
<td>ASA score</td>
<td>2.5 ± 0.57 [1–3]</td>
</tr>
<tr>
<td>Number of previous revisions</td>
<td>1.95 ± 1.2 [1–7]</td>
</tr>
<tr>
<td>Side</td>
<td>35 right, 27 left</td>
</tr>
</tbody>
</table>

BMI: body-mass index; ASA: American Society of Anesthesiologists.

Table 3

<table>
<thead>
<tr>
<th>Indications</th>
<th>SoFCOT grade</th>
<th>Reinforcement</th>
<th>Type of revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aseptic loosening and polyethylene wear n = 44</td>
<td>Grade 2: 2</td>
<td>Müller®: 33</td>
<td>23 unipolar</td>
</tr>
<tr>
<td>Instability n = 7</td>
<td>Grade 2: 1</td>
<td>Müller®: 4</td>
<td>5 unipolar</td>
</tr>
<tr>
<td>Septic loosening n = 11</td>
<td>Grade 2: 1</td>
<td>Müller®: 10</td>
<td>11 bipolar</td>
</tr>
<tr>
<td>Total</td>
<td>Grade 2: 4</td>
<td>Müller®: 37</td>
<td>28 unipolar</td>
</tr>
<tr>
<td>Grade 3: 45</td>
<td>Burch®: 8</td>
<td>34 bipolar</td>
<td></td>
</tr>
<tr>
<td>Grade 4: 9</td>
<td>Link®: 3</td>
<td>4 unchanged</td>
<td></td>
</tr>
</tbody>
</table>


Table 4

<table>
<thead>
<tr>
<th>Metal head</th>
<th>Cup</th>
<th>Bipolar revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.2 mm n = 2</td>
<td>Diameter 48: n = 2</td>
<td>1 case</td>
</tr>
<tr>
<td>28 mm n = 20</td>
<td>Diameter 48: n = 14</td>
<td>12 cases</td>
</tr>
<tr>
<td>Diameter 52: n = 4</td>
<td>Diameter 56: n = 2</td>
<td></td>
</tr>
</tbody>
</table>
There were 7 cases of revision for infection: 3 de novo early infections, within the first 3 months, were treated by lavage and antibiotic therapy in the acute phase within 3 weeks of onset. Four recurrences were managed by 2-step explantation–reimplantation.

One early traumatic dislocation was reduced by external maneuver, without recurrence. Aseptic loosening occurred at a mean 8.8 ± 3.9 months.

3.4. Analysis of failure risk factors

One risk factor for loosening emerged: cement thickness ≤ 2 mm \( (P=0.049) \). Gender \( (P=0.37) \), reason for revision \( (P=0.1) \), operated side \( (P=0.1) \), number of previous surgeries \( (P=0.33) \), overweight \( (P=0.58) \), or uni- vs. bipolar revision \( (P=0.42) \) were not significant risk factors for loosening \( (P=0.42) \).

There was a statistical trend toward loosening for reinforcement size ≤ 50 mm.

There were no significant correlations between intraoperative assessment of acetabular lesion severity on the SoFCOT criteria and risk of loosening.

Eight-year implant survival, censored for instability or aseptic loosening, was 91.9% (Fig. 5).

4. Discussion

During these revision procedures, acetabular injury required bone defect filling by femoral head-bank allograft \([18,19]\) with metal reinforcement protection \([20,21]\).

The choice between Müller\® rings, Burch\® rings or Link\® reinforcement was guided by the severity of the acetabular lesions found intraoperatively, and notably by pelvic ring rupture. Some authors use Kerboull crosses in this type of reconstruction \([5]\), but we have no experience of this in our department.

Dual-mobility cups cemented in a metal reinforcement have been reported in several series \([5,9–13]\). The present clinical results were comparable in terms of MAP and HHS scores at last follow-up (Table 5). At last follow-up, Oxford-12 was also used to assess the service provided to the patient, and was considered good or very good in almost 79% of cases \([16]\).

One of the main risks in THA revision is instability, with rates up to 20% depending on the series \([1,2]\).

Uncemented dual-mobility cups are known to show greatly reduced risk of dislocation on revision, at 2–9%, depending on the cause of revision \([3–6]\). This was confirmed in the present series, with a rate of postoperative dislocation of only 1.6%, comparable to other reports for the same type of assembly, but with longer mean follow-up (Table 5). As in other reports, dislocation was systematically early, and there were no cases of intra-prosthetic dislocation, probably due to insufficient follow-up, as this specific complication of dual-mobility cups generally occurs only after 8 years \([22]\).

Philippot et al. \([5]\) found 2 situations associated with high risk of dislocation: revision for implant instability, and reimplantation for chronic infection. This was not seen in the present series, where classic dislocation factors did not emerge.

The other risk assessed here was loosening. Direct bone cementing of fixed-insert metal-back implants is notoriously associated with high short- and long-term rates of failure, with 20–40%
loosening on radiography [23,24]. In contrast, Haen et al. [7] reported good clinical results in THA revision with dual-mobility cups cemented directly in the bone; 5-year survival was 98%, although for small acetabular bone defects and at short follow-up.

As early as 1986, Meyrueis et al. [25] suggested that cementing a metal implant should systematically use a reinforcement screwed into the acetabulum; this was later confirmed by Bonnomet et al. in 2001 [26], then by Girard et al., who found a low rate of loosening with metal implants cemented in a reinforcement, although this was for a metal-metal frictional couple, at 5 years’ follow-up [20].

In the literature, rates for aseptic loosening of dual-mobility cups cemented in a reinforcement range between 0 and 2.2% [5,10–13], whereas in the present series the rate was higher, at 6.4% at almost 6.5 years’ mean follow-up (Table 5).

We consider cementing quality to be a determining factor of assembly stability. Wegryn et al. [8] reported good biomechanical resistance in dual-mobility cups cemented in a reinforcement, with lever and torsion resistance 100-fold greater than actual in-vivo mechanical stress levels. In vitro, Ebramzadeh et al. [15] found that cement thickness of 2 mm or less between reinforcement and cup incurred greater risk of loosening than thicknesses of 4 mm or more. In the present study, there was a significant correlation between early loosening of the cup within the reinforcement and cement thickness ≤ 2 mm. There was also a trend toward loosening for 50 mm diameter reinforcements. This may be because there were only 4 diameters available for the cup used in the present series, limiting the possibility of adequate cement thickness between the two components: when a monobloc stem and 28 mm head was not to be replaced, a minimum cup diameter of 48 mm was required; or, if the femoral stem allowed a 22 mm head and thus a 44 mm cup, a 48 mm cup was nevertheless chosen; in either case, a 50 mm reinforcement limited cement thickness between the two components. Failure to change the stem in such cases so as to be able to use a 22.2 mm head and thus a 44 mm cup may be criticized, as may the choice to use a cup with dimensions too close to those of the reinforcement. Since 2012, it has been easier to have a space of at least 4 mm between components, thanks to the introduction of intermediate sized cups with 2 mm stepwise increments, allowing more precise adaptation to the reinforcement diameter. Progress in cup design (Fig. 1), with a new circumferential groove and longitudinal grooves, should improve implant sealing; the longitudinal grooves absorb rotational stress. This may explain the improved results in terms of loosening in similar series [10–13] in which the cup has transverse and longitudinal grooves on the metal-back, to improve sealing.

The present failure rate, excluding infection, was 8.1%, mainly involving early loosening, compared to 4–21.9% in comparable series [9–13], although Philippot et al. [5], Pattyn and Audenaert [13] and Civinni et al. [12] reported heterogeneous series also including dual-mobility cups impacted directly in the bone and cups with hooks and direct bone screwing.

In the present series, there were no aseptic loosenings beyond 2 years postoperatively, which is an encouraging finding for medium-term survival in case of good-quality primary cementing.

All patients without follow-up were contacted; thus no failures or complications were overlooked, enhancing the strength of the

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**Table 5**

Results and complications for dual-mobility cups cemented in a reinforcement.

<table>
<thead>
<tr>
<th>Series</th>
<th>Implants</th>
<th>Mean follow-up (years)</th>
<th>Clinical scores</th>
<th>Dislocation rate (%)</th>
<th>Aseptic loosening (%)</th>
<th>Revision (excl. infection) (%)</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langlais et al., 2008 [10]</td>
<td>Medal + DMC (n = 82) + Kerbouli cross</td>
<td>3</td>
<td>MAP 16.1</td>
<td>1.1</td>
<td>2.2</td>
<td>8</td>
<td>94.6% at 5 years</td>
</tr>
<tr>
<td>Schneider et al., 2011 [11]</td>
<td>Novae + Burch + ARM</td>
<td>3.4</td>
<td>MAP 15.5</td>
<td>10.4</td>
<td>1</td>
<td>4.2</td>
<td>95.6% at 8 years</td>
</tr>
<tr>
<td>Philippot et al., 2009 [5]</td>
<td>Novae + Kerbouli cross + ARM</td>
<td>5</td>
<td>MAP 14.8</td>
<td>3.6</td>
<td>1.2</td>
<td>6.7</td>
<td>96.1% at 7 years</td>
</tr>
<tr>
<td>Civinni et al., 2012 [12]</td>
<td>Avantage + (n = 33)</td>
<td>2</td>
<td>HHS 86 Womac 19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>97% at 5 years</td>
</tr>
<tr>
<td>Pattyn and Audenaert, 2012 [13]</td>
<td>Apogée (n = 37)</td>
<td>1.3</td>
<td>MAP 14</td>
<td>1.6</td>
<td>6.4</td>
<td>8.1</td>
<td>91.9% at 8 years</td>
</tr>
<tr>
<td>Present series</td>
<td>Quattro + (n = 62) + Müller + Burch + Link</td>
<td>6.4</td>
<td>HHS 73 Oxford 23.9</td>
<td>1.6</td>
<td>6.4</td>
<td>8.1</td>
<td>91.9% at 8 years</td>
</tr>
</tbody>
</table>

MAP: Merle–d’Aubigné–Postel score; HHS: Harris Hip Score.
study. The weak points, however, are the retrospective design and heterogeneous recruitment, with both uni- and bipolar revisions and a variety of causes. Follow-up was relatively short; however, in the literature, cup-reinforcement loosening occurs early.

5. Conclusion

Dual-mobility cups cemented in a metal reinforcement fulfilled the charge-book in terms of reduced dislocation risk in THA revision, and gave encouraging results.

Cup loosening within the reinforcement is a specific and early complication, which in the present series seemed to be related to:

- insufficient cement thickness between reinforcement and cup, due to a limited range of implant sizes;
- and, probably, the first-generation cup design.

It seems essential to have a cement thickness of at least 2 mm between reinforcement and cup, to limit the risk of early loosening.

Disclosure of interest

P. Mertl is occasional consultant for De Puy, Stryker, B-Braun et Zimmer. The other authors declare that they have no competing interest.

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[26] Bonnomet F, Clavert P, Gicquel P, Lefebvre Y, Kempf JF. Reconstruction by graft and revision device in severe aseptic acetabular loosening: 10 years sur-