Prevention of dislocation in total hip revision surgery using a dual mobility design

Prévention de la luxation par la double mobilité lors de reprise d’arthroplastie totale de hanche

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Summary
Background: Postoperative dislocation is the commonest complication following revision total hip arthroplasty (THA).
Hypothesis and type of study: Dual mobility cups are supposed to reduce the risk of THA instability. The present retrospective study tested this hypothesis on revision THAs and also, assessed this design contribution to acetabular fixation longevity.
Materials and methods: The series was homogeneous and continuous, comprising a total of 163 revision THAs: 110 of them were bipolar revisions and 53 were restricted to the acetabular component exchange. Mean patient age was 68.7 years (range: 34—92 years). Novae™ (SERF, Décines) dual mobility cups were used in all cases: 110 cementless cups were used and 53 cups were cemented in a Kerboull reinforcement ring due to severe acetabular bone loss.
Results: Mean patients’ follow-up (FU) was 60.4 ± 17.6 months. There were six early dislocations (which were reduced without additional surgery and remained recurrence-free) and two cases of acetabular loosening. The total postoperative dislocation rate at the end of follow-up was 3.7% and the 7-year cup survivorship rate was 96.1% (95% CI: 92.8—99.2%). In revision for aseptic loosening, the instability rate was 2.9%; in the higher instability risk groups (i.e., revision for infection and or recurrent instability) the dislocation rate was respectively 9% and 0%.
Discussion: Dual mobility cups provided a dislocation rate of only 3.7% in revision THA, comparable to the one reported with standard implants for primary THA. This kind of cup design...
is especially suited to deal with high instability risk revision cases, where constrained components are generally recommended. It can also be indicated in cases of aseptic loosening, where it resulted in a 2.9% dislocation rate and only two impending failures of fixation. In terms of mechanical failure rate, these numbers compare well to the ones pertaining to triplor and constrained implants. These later alternatives remain possible options but are not fully efficient in terms of long-term stability and fixation longevity.

**Level of study.** Level IV, retrospective or records-based.

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**Introduction**

A 2 to 5% rate of postoperative dislocation following primary total hip arthroplasty (THA) has been reported in large series [1,2]. In revision THA, factors such as muscular insufficiency, enlarged synovectomy, implant positioning problems or the need for bone reconstruction have been implicated in postoperative instability. Depending on the reasons for revision, mean dislocation rates in the literature range from 5 to 30% [3–6]. Constrained or tripolar cup designs have reduced postoperative dislocation rates, but only to a limited extent and to the detriment of long-term acetabular fixation [7–11].

The dual mobility concept was introduced by Gilles Bousquet to reduce the rate of postoperative dislocation. Some studies of dual mobility cups deployed in primary surgery reported very low rates of postoperative implant instability [12–14]. The dual mobility design has also proved its worth in revision surgery for chronic implant instability [15,16]. The present study assessed the interest of dual mobility cups in revision THA in a continuous retrospective series of uni- or bipolar revision, focusing on postoperative dislocation rates and long-term implant fixation.

**Material and methods**

**Patients**

The study concerned a homogeneous continuous series of 163 revision THAs performed in two teaching hospitals between January 1999 and December 2004. All patients undergoing acetabular revision using a dual mobility cup were included; simple polyethylene insert replacement and unipolar femoral revision were excluded. Mean patient age was 68.7 years (34–92), 103 females and 60 males. Seventy patients had single-joint damage (Charnley A), 163 revision THAs performed in two teaching hospitals

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41. 38 Nova Sunfit™ cups (SERF, Décines). This is a cylindro-hemispheric stainless steel cup with cementless press-fit fixation ensured by equatorial macrostructures and a bilayer coating comprising an Al₂O₃ alumina plasma undercoat and a hydroxyapatite plasma top coat. This model was used in case of AAOS stage-I bone loss;

2. 51 Nova Stick™ cups (SERF, Décines, France). This is a cylindrohemispheric stainless steel cup, intended to be cemented. It is identical to the Nova Sunfit™ cup except that the macrostructures cover the entire surface, without coating. This model was used when cementing was required, with either a Nova Arm™ acetabular component (seven cases) or a Kerboull cross (44 cases);

3. 58 Nova-1™ cups (SERF, Décines). This is a cylindro-hemispheric stainless steel cup with cementless so-called “tripod” press-fit fixation, having two deep anchoring plots and a superior mooring screw with a recommended 45° iliac orientation. The coating is the same as in the Nova Sunfit™ cup. This model was used in case of AAOS stage I or II bone loss;

4. 16 Nova Coptos™ cups (SERF, Décines, France). This is a hemispheric stainless steel cup with cementless press-fit fixation, identical to the Nova Sunfit™ cup but with two superior feet, each receiving two screws, and an inferior obturator hook to enhance stability. This model was used in case of AAOS stage II or III bone loss.

Stainless steel Nova Arm™ acetabular components (SERF, Décines, France) and Kerboull™ crosses (Stryker-Howmedica) were used for AAOS stages III and IV. Such reinforcements were always fitted using the same protocol: positioning and fixing the reinforcement in healthy bone, acetabular floor allograft using an irradiated and cryopreserved bone-bank head, then cementing the Nova stick cup into the reinforcement.

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Acetabular implant characteristics

Only dual mobility cups were used. The mobile insert providing dual articulation between metalback and head was in UHMWPE polyethylene, which, being retentive, was force-impacted on to the implant head. The heads were all in cobalt–chrome alloy, with a 22.2 mm diameter. This gave the implant a slight mobility between the implant head and the concave side of the polyethylene insert, and a great mobility between the convex side of the insert and the polished concave surface of the stainless steel cup.

All of the implants were of the Novaetm™ range (SERF, Décines):

- 38 Nova Sunfit™ cups (SERF, Décines). This is a cylindro-hemispheric stainless steel cup with cementless press-fit fixation ensured by equatorial macrostructures and a bilayer coating comprising an Al₂O₃ alumina plasma undercoat and a hydroxyapatite plasma top coat. This model was used in case of AAOS stage-I bone loss;
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Table 1  Dual mobility cup survivorship (failure defined as surgical revision for aseptic loosening of the component).

<table>
<thead>
<tr>
<th>Interval (months)</th>
<th>Number of events (n)</th>
<th>Number at risk (n)</th>
<th>Cumulative survival</th>
<th>Cumulative failure</th>
<th>Standard deviation (survival)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0—10</td>
<td>0</td>
<td>163</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10—20</td>
<td>0</td>
<td>163</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20—30</td>
<td>0</td>
<td>159</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30—40</td>
<td>1</td>
<td>144</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40—50</td>
<td>1</td>
<td>116.5</td>
<td>0.993</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>50—60</td>
<td>0</td>
<td>85.5</td>
<td>0.993</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>60—70</td>
<td>0</td>
<td>55.5</td>
<td>0.993</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>70—80</td>
<td>1</td>
<td>31</td>
<td>0.993</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>80—90</td>
<td>0</td>
<td>20</td>
<td>0.961</td>
<td>0.039</td>
<td>0.032</td>
</tr>
</tbody>
</table>

Assessment methods

All patients had regular clinical and X-ray follow-up (FU). Clinical assessment used Postel Merle d’Aubigné scoring [18], and X-ray assessment was based on AP pelvic and AP and lateral hip images. For the cup, radiolucency, osteolyses and cavities were identified and located by Delee and Charnley zones [19]. On the femoral side, signs of loosening were identified and located in terms of the zones described by Gruen et al. [20]. Heterotopic ossification was classified following Brooker et al. [21].

Cup survivorship at end of FU was analyzed actuarially [22] (with CI > 95%), with failure defined as any surgical revision for aseptic loosening. The incidence of implant dislocation at end of FU was studied by recording all dislocation episodes; the main dislocation risk factors were predefined (age, sex, approach route, and number of previous interventions) and significant differences were sought between patients with and without postoperative dislocation episodes. Statistical analysis on Statview™ software used univariate parametric tests, with the significance threshold set at p < 0.05.

Results

At end of FU, six patients had died and one was lost to FU. Mean Postel Merle d’Aubigné score had risen from 8.2 (2.4 for pain, 3 for mobility, and 2.8 for walking ability) preoperatively to 14.8 (5.4 for pain, 5 for mobility, and 4.4 for walking ability). Mean FU was 60.4 ± 17.6 months (24—112). End of FU X-ray analysis found three evolutive radiolucent areas in Delee and Charnley zone III and two in zone II.

Failure and complications

Perioperative complications comprised: two greater trochanter fractures and one supracondylar fracture managed by plate fixation. There was also one immediate postoperative common fibular nerve paralysis.

Postoperative complications comprised:

• six early dislocations (3.7%), within 6 months, none requiring surgical revision (reduction was obtained after close manipulation);
• two fractures under the femoral implant (1.2%), at 36 and 42 months respectively;
• five infections (3%), including two early infections managed by simple surgical lavage, and 3 deep infections requiring implant removal at 15, 18 and 20 months, respectively;
• two cases of greater trochanter nonunion (1.2%);
• one femoral implant fracture (0.6%) at 36 months, requiring surgical revision;
• two cases of cup loosening (1.2%): one traumatic, at 2 months, and the other aseptic and nontraumatic, at 15 months;
• one polyethylene component replacement (0.6%) at 48 months, for severe early wear.

The overall postoperative dislocation rate at end of FU was 3.7%. There was no recurrence of early dislocation. All cases could be managed by external maneuver under general anesthetic and curarization. None were complicated by subsequent intraimplant dislocation. The overall end of FU rate of surgical revision for whatever reasons was 6.7%, and 1.2% (two cases) for failed cup fixation.

Two subgroups at particular risk of postoperative instability—revision for recurrent dislocation (26 cases), and reimplantation following deep infection (33 cases)—showed postoperative dislocation rates at end of FU of respectively 0% and 9% (equal to three cases). In the subgroup of revision for aseptic loosening (104 cases), the end of FU dislocation rate was 2.9% (equal to three cases).

Statistical analysis

Seven-year dual mobility cup survivorship, with failure defined as revision surgery for aseptic loosening, was 96.1% (95% CI: 92.8—99.2%) (Table 1). None of the predefined risk factors (age, sex, approach route, and number of previous interventions) significantly affected dislocation rates in the present series, and none could thus be assigned any positive predictive value for postoperative dislocation.
Table 2  Comparison of dislocation and acetabular failure rates in series of revision THA secondary to deep infection.

<table>
<thead>
<tr>
<th>Series</th>
<th>Cup type</th>
<th>Number of cases</th>
<th>Mean FU (months)</th>
<th>Dislocations n (%)</th>
<th>Revision for aseptic failure n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hartman and Garvin [26]</td>
<td>Single mobility standard cup</td>
<td>34</td>
<td>24</td>
<td>5 (15%)</td>
<td>NS</td>
</tr>
<tr>
<td>Berend et al. [32]</td>
<td>S-ROM™</td>
<td>60</td>
<td>120</td>
<td>13 (21.4%)</td>
<td>15 (25%)</td>
</tr>
<tr>
<td>Charlton et al. [27]</td>
<td>Single mobility standard cup</td>
<td>44</td>
<td>24–108</td>
<td>6 (14%)</td>
<td>NS</td>
</tr>
<tr>
<td>Present series</td>
<td>Dual mobility cup</td>
<td>33</td>
<td>60</td>
<td>3 (9%)</td>
<td>0</td>
</tr>
</tbody>
</table>

Discussion

Series as a whole

Our analysis of the present revision THA series focused especially on the postoperative dislocation rate. The usual rates in the literature, for standard implants, range from 5 to 30% [4,6,23,24], compared to 3.7% in the present series of dual mobility cups—i.e., close to the rate found with standard implants used in primary surgery. Most published series do not identify revision for recurrent dislocation or reimplantation following deep infection. The present results, however, highlighted reimplantation following deep infection (33 cases) as the situation at highest risk of postoperative dislocation. To clarify the discussion, we therefore distinguish three subgroups in the present series: reimplantation following deep infection (33 cases), recurrent dislocation (26 cases), and aseptic loosening (104 cases).

Reimplantation following deep infection

Vielpeau and Lortat Jacob [25] describe the various instability risk factors for reimplantation following deep infection: muscular atrophy secondary to prolonged immobilization, the enlarged synovectomy required during reimplantation, significant muscle retraction (especially when traction or a temporary spacer were not used to maintain the joint space), tricky and uncertain implant positioning in what tends to be poor-quality bone, and unequal residual limb length (Table 2). In the present subgroup of 33 reimplantations following deep infection, there were three cases (equal to 9%) of postoperative dislocation, which is quite a good result compared to the few published series of revision THA for infection (see Table 2). Hartman and Gavin [26] and Charlton et al. [27] respectively reported 15% and 14% postoperative dislocation in 34 and 44 reimplantations following deep infection. Charlton et al. [27] concluded by strongly recommending the use of constrained cups, given their high postoperative dislocation rate. Dual mobility cups have a clear role to play in these high dislocation risk situations, reducing the rate of postoperative instability.

Revision for recurrent dislocation

For the recurrent dislocation subgroup, the present series merely confirms the extensive literature findings (see Table 3). In the subgroup of 26 patients, there was no recurrence of dislocation and the dual mobility concept once again seemed to be highly effective in terms of stability. Additional elevated posterior wall certainly reduce postoperative dislocation [28,29] but only to a limited extent as they entail a risk of dislocation in the opposite direction. Moreover, by increasing implant constraint with reiterated conflict between neck and elevated rim, they lead to the release of polyethylene particles into the joint, thus potentially increasing the risk of later loosening [30]. Some authors recommend using constrained cups in this indication [31], but published results still show high rates of residual dislocation of between 3 and 28%, with up to 17% mechanical failure [32,33].

Table 3  Comparison of dislocation and acetabular failure rates according to cup type (constrained or nonconstrained) in revision THA for recurrence of dislocation.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Cup type</th>
<th>Number of cases</th>
<th>Mean FU (months)</th>
<th>Dislocation n (%)</th>
<th>Revision for aseptic failure n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toomey et al. [29]</td>
<td>Polyethylene antidislocation crescent</td>
<td>13</td>
<td>72</td>
<td>3 (23%)</td>
<td>0</td>
</tr>
<tr>
<td>Gholve et al. [28].</td>
<td>PLAD™ antidislocation crescent</td>
<td>21</td>
<td>17</td>
<td>2 (9.5%)</td>
<td>0</td>
</tr>
<tr>
<td>Berend et al. [32]</td>
<td>S-ROM™</td>
<td>138</td>
<td>120</td>
<td>40 (28.9%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Callaghan et al. [40]</td>
<td>Tripolar™</td>
<td>56</td>
<td>48–120</td>
<td>4 (7%)</td>
<td>4 (7%)</td>
</tr>
<tr>
<td>Khan et al. [33]</td>
<td>Trident constrained acetabular cup™</td>
<td>34</td>
<td>36</td>
<td>1 (3%)</td>
<td>6 (17%)</td>
</tr>
<tr>
<td>Beaule et al. [10]</td>
<td>Jumbo Head™</td>
<td>12</td>
<td>72</td>
<td>1 (8%)</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Present series</td>
<td>Dual mobility cup</td>
<td>26</td>
<td>60</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4  Comparison of dislocation and acetabular failure rates, according to cup type and to degree of bone loss, in revision THA for aseptic loosening.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Cup type</th>
<th>Number of cases</th>
<th>Bone loss distribution (AAOS classification)</th>
<th>Mean FU (months)</th>
<th>Dislocation (n) (%)</th>
<th>Revision for aseptic loosening (n) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parratte et al. [23]</td>
<td>Hilock Rev™</td>
<td>34</td>
<td>III : 100%</td>
<td>72</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Pieringer et al. [35]</td>
<td>Burch-Schneider™ cage</td>
<td>67</td>
<td>II : 30%</td>
<td>50</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III : 70%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bostrom et al. [34]</td>
<td>Burch-Schneider™ cage</td>
<td>31</td>
<td>II : 7%</td>
<td>30</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III : 74%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>IV : 19%</td>
<td></td>
<td></td>
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<tr>
<td>Unger et al. [36]</td>
<td>Monoblock Acetabular Cup System™</td>
<td>60</td>
<td>I : 2%</td>
<td>42</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>II : 86%</td>
<td></td>
<td></td>
<td>3.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III : 12%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kawanabe et al. [37]</td>
<td>Kerboull™ reinforcement device with single mobility cup</td>
<td>46</td>
<td>II : 31%</td>
<td>105</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III : 67%</td>
<td></td>
<td>8%</td>
<td>2.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IV : 2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present series</td>
<td>Dual mobility ± reinforcement</td>
<td>104</td>
<td>I : 26%</td>
<td>60.4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>II : 33%</td>
<td></td>
<td>2.8%</td>
<td>1.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III : 28%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>IV : 13%</td>
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</tbody>
</table>
Revision for aseptic loosening

The end of FU postoperative dislocation rate in the subgroup of revision THA for uni- or bipolar aseptic loosening was 2.9% (Table 4). Many published series using standard cups report much higher rates of between 5 and 30% [23,34–38], and the dual mobility concept emerges as a clear improvement in terms of preventing dislocation. Constrained and triportal implants have been recommended by some authors where the risk of postoperative dislocation is high. Constrained implants use implant head retention to reduce instability [8]. Stability is indeed achieved, but the great increase in interface constraint entails a risk of long-term fixation failure, which is the main drawback of this technique [11]. The increase in interface constraint is due to considerably reduced joint amplitude, as the way the implant functions tends to induce impingement, as Murray [39] pointed out for nonconstrained implants involving an antidislocation long posterior wall. The polyethylene component is, moreover, thin in these designs. The risk of long-term fixation failure is increased in revision surgery, where there is often bone loss and poor bone quality. Secondary implant fixation quality is an essential objective, making increased interface constraint counterproductive. Triportal cups, such as the Tripolar™ model (Osteonics Corp, Allendale, NJ), also meet the objective of stability [40], and their enhanced joint amplitude reduces interface constraint by limiting mechanical conflict. The drawback of the triportal concept lies in the greater number of interfaces, which doubtless accounts for the excessive incidence of aseptic loosening reported in the literature [40,41].

We therefore give preference to dual mobility cups, which show 7-year survivorship (with failure defined as surgical revision for aseptic cup loosening) of 96% (95% CI: 92.8–99.2%), although FU in the present series was only 60.4 months, so that many events may be yet to come. Studies of implant fixation in revision THA, however, report survivorship values very comparable to those for the present series [23,34–37]. More specifically regarding AAOS stages III and IV acetabular bone loss (with 56 cases in the present series), we found no acetabular failure at end of FU, whereas Parratte et al. [23] and Kerboull et al. [42], in comparable series, reported rates of respectively 5.8% and 5% at 6 and 8 years. Thus the dual mobility design does not seem to have a negative impact on acetabular fixation and can be used in all situations of revision involving bone defect, from stage I to stage V, with or without the use of reinforcements or graft.

Conclusion

Our overall postoperative dislocation rate of 3.7% at end of FU in a series of revision THA using a dual mobility cup confirms that this design provides stability, at least up to medium term. This conclusion holds for each of our three subgroups, corresponding to three precise clinical situations: reimplantation following deep infection, recurrent dislocation, and aseptic loosening. With 7-year survivorship of 96% ± 3.2%, the dual mobility design appears to provide better fixation than the constrained or triportal cups often recommended in these indications. Our FU was relatively short, but the quality of the results in terms of both stability and secondary fixation indicates that dual mobility cups are an attitude of choice in revision THA, with or without bone defect.

References


