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Original article

Risk factors for dislocation after revision total hip arthroplasty with a dual-mobility cup. Matched case-control study (16 cases vs. 48 controls)

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ABSTRACT

Background: Reports of high dislocation rates after revision total hip arthroplasty (THA) have encouraged the widespread use of dual-mobility cups. Dislocation has been less common but not fully abolished with dual-mobility cups, and its causes have remained unidentified. The objectives of this retrospective matched case-control study were: 1) to identify risk factors for dislocation, 2) and to assess dislocation outcomes.

Hypothesis: The causes of dislocation after revision THA with a dual-mobility cup can be identified.

Material and method: Among 653 consecutive patients identified retrospectively as having undergone revision THA with a dual-mobility cup (Medial Cup, Aston, Saint-Étienne, France) between January 2007 and December 2017, 16 (2.45%) subsequently experienced dislocation, after a mean of 3.6 months (range, 0.9–19 months). For each of these 16 patients, we collected the main patient characteristics (age, sex, body mass index [BMI], ASA score, and reason for the initial arthroplasty procedure), local history (number of previous surgical procedures, reason for revision, femoral and acetabular bony defects classified according to Paprosky, and status of the abductor apparatus), and characteristics of the revision (approach, diameters of the cup and femoral head, cup inclination, femoral offset, lower limb length, and implant anteversion). Controls were patients without dislocation after revision dual-mobility THA. Each of the 16 patients was matched to 3 controls on age (±10 years), sex, year of revision, and whether revision was only acetabular or bipolar. Univariate and multivariate analyses were done to compare the cases and controls, and dislocation outcomes in the cases were evaluated.

Results: By univariate analyses, factors associated with dislocation were BMI > 30 (cases, 37.5%; controls, 10.4%; $p = 0.02$), larger number of previous surgical procedures on the same hip (cases, 2.8; controls, 1.8; $p = 0.004$), larger number of arthroplasties (cases, 2.3; controls, 1.5; $p = 0.004$), history of instability (cases, 31% with chronic dislocation and 13% with recurrent dislocation; controls, 6.25% and 2.1%, respectively; $p = 0.004$), and compromised abductor apparatus (cases, 56.25%; controls, 14.6%; $p = 0.002$). Independent risk factors for dislocation identified by multivariate analysis were instability (odds ratio [OR], 14.5; 95% confidence interval [95%CI], 1.5–149.9) and, most importantly, abductor apparatus compromise (OR, 43.1; 95%CI, 3.18–586.3). Of the 16 cases, 1 was lost to follow-up, 1 had contra-indications to anaesthesia, 1 died after several dislocation episodes, and 1 died 3 months after surgical reduction. In 5 cases, there was a single dislocation episode. Further surgery was performed in 8 cases (surgical reduction, $n = 1$; constrained cup, $n = 3$; trochanteric internal fixation, $n = 1$; exchange of the dual-mobility cup, $n = 2$, including 1 with subsequent dislocation episodes; and femoral component exchange followed by a retentive cup due to further dislocation episodes, $n = 1$).

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Conclusion: Risk factors for dislocation consisted of a history of instability and, most importantly, abductor apparatus compromise. A constrained cup should be considererd in patients with impaired abductor apparatus. No further dislocations occurred after reduction of the first episode in 31.25% of cases. Recurrent dislocation should prompt measures to correct impaired abductor apparatus whenever possible, as well as correction of any component malposition. Whether a retentive cup should be implanted routinely remains unclear.
Level of evidence: III, matched case-control study.

1. Introduction

Reports of high dislocation rates after revision total hip arthroplasty (THA) have encouraged the widespread use of dual-mobility cups (DMCs). However, dislocation rates ranging from 0% to 5% have been reported after dual-mobility THA revision for any reason [1–12] (Table 1) or for instability [17–26] (Table 2). Higher rates of 5%–10% [13–15,27] and 17% [16] were found in some studies.

The risk factors for instability after revision hip arthroplasty using a dual-mobility cup (ReDMC) are unknown, as most studies of dislocation rates failed to identify the causes of dislocation, one reason being the absence of a control group. Furthermore, data on dislocation outcomes were usually not collected.

The objectives of this retrospective matched case-control study were: 1) to identify risk factors for dislocation, 2) and to assess dislocation outcomes. Our working hypothesis was that causes of dislocation after ReDMC could be identified.

2. Material and methods

2.1. Patients

Among 653 retrospectively identified consecutive patients in whom ReDMC was performed by senior and junior surgeons at the Rennes university hospital (Rennes, France) between 1st January 2007 and 31st December 2017, 16 subsequently experienced hip dislocation. They constituted the group of cases in this case-control study. For each case, we collected the main patient characteristics (age, sex, body mass index [BMI], ASA score [28], reason for the initial arthroplasty procedure, and side) (Table 3), the local history (number of previous conservative and prosthetic procedures on the same hip, reason for revision, whether there was a former history of dislocation and if it was chronic or recurrent, whether loosening was also present, the size of the acetabular and femoral bony defects classified according to Paprosky [29,30], and the status of the abductor apparatus (non-union of the greater trochanter, classified as loose if the displacement was greater than 1cm; absence of the greater trochanter; and/or rupture of the gluteus and minilus muscles) (Table 4).

2.2. Revision techniques

The revision was acetabular only in 10 cases and bipolar in 6 cases. In all 16 cases, ReDMC was performed using the Medial Cup (Aston, Saint-Étienne, France), which has an outer profile similar to that of the Charnley cup with a thinner dome that medialises the centre of rotation of the insert relative to that of the cup. The following characteristics of each ReDMC procedure were collected (Table 5): approach, type of acetabular reconstruction, cup diameter, femoral head diameter, cup inclination relative to the teardrop, femoral offset (distance in millimetres between the centre of the joint and the axis of the femoral shaft), and final lower-limb length (from the teardrop to the centre of the lesser trochanter). In addition, in 9 cases implant version was measured on computed tomography (CT) images. The data in Table 5 illustrate the heterogeneity of the ReDMC procedures, which is ascribable to changes in surgical techniques over the 11-year study period.

2.3. Assessment methods

The 48 controls were patients who remained free of dislocation after ReDMC. Each case was matched to 3 controls on age ± 10 years (cases, 74.3 years [range, 62–90 years]; controls, 71.4 years [range, 56–92 years]), sex (cases, 13 females and 3 males; controls, 39 females and 9 males), year of revision, and whether revision was acetabular only or bipolar (controls, 30 acetabular and 18 bipolar). The above-listed variables collected in the cases were collected in the controls and then compared betweeen the two groups by univariate and multivariate analyses. Finally, the treatments used to treat the dislocations and their outcomes were recorded.

2.4. Statistical methods

The statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA). Qualitative variables were described as number (%) and quantitative variables as mean ± SD if normally distributed and as median (with extreme values) otherwise. Student's t-test or Wilcoxon's test was applied to compare quantitative variables and the Chi^2 test or Fisher's exact test to compare qualitative variables. Multivariate analyses were performed using ascending stepwise conditional logistic regression. The variables considered for the multivariate models were those associated with p values < 0.2 by univariate analysis. The 95% confidence intervals (95%CIs) were computed. Values of p smaller than 0.05 were taken to indicate significant differences.

3. Results

There were no missing data for the risk factor analysis. Tables 3–5 indicate the potential impact of risk factors. Mean time from ReDMC to dislocation was 3.6 ± 4.5 months (range, 0.7–19.0 months).

Before revision chronic dislocation with acetabular or bipolar loosening was present in 3 cases and 2 controls. Trochanteric non-union was loose in all 7 cases and in 7 controls with this feature (Table 4). Trochanteric non-union was used for the surgical approach in 2 cases and 3 controls and was then fixed at the end of the procedure (Table 5).

Risk factors by univariate analysis were as follows: BMI > 30, a higher number of previous surgical procedures, a higher number of previous prosthetic surgical procedures, chronic dislocation or recurrent dislocation, and abductor apparatus compromise (Tables 3–5). The multivariate analysis identified two independent risk factors, namely, pre-operative instability of the prosthetic hip and, most importantly, abductor apparatus compromise (Table 4).

CT performed in 9 cases showed acetabular retroversion in 2 (7° and 12°, respectively), femoral retroversion in 1 patient (22°), and absence of femoral anteversion in 1 patient (0°).

Table 1
Case-series studies of revision surgery with dual-mobility cup implantation for any reason.

Authors	*N*	Follow-up	Dislocation	Loosening
Langlais et al. [1]	85	3 years (2–5)	1.2%	No revision: 2.3%
Philippot et al. [2]	163	60.4 months (24–12)	3.7% (single episode)	Revision: 1.2%
Schneider et al. [13]	96	41 months (1–101)	10.4% Surgical reduction: 3%	Revision: 2% Cage breakage: 7% (no revision)
Civinni et al. [3]	33	3 years (2–5)	0%	0%
Prudhon et al. [4]	78	> 2 years	1.3%	2.7%
Simian et al. [5]	74	88 months (60–137)	1.3%	1.3%
Mohammed et al. [6]	44	22 months (6–63)	0%	
Viste et al. [8]	334	7 years (5–10)	3.3% (single episode, 1.2%)	3% Cage breakage: 3.3% (no revision)
Massin and Besnier [14]	23	4.5 years (2–10)	8.7% (NOT)	Revision: 4.3%
Pattyn and Audenaert [15]	37	16 months (6–27)	5.40% (NOT)	
Wegzryn et al. [10]	61	89 months (60–138)	0%	1.5%
Wegzryn et al. [11]	994	7.3 years	1.5% (NOT: 0.5%) IPD: 0.2%	
Jauregui et al. [12]	60	2.5 years	1.7%	
Chalmers et al. [16]	18	2 years	17% Surgical reduction 5.5% Revision 11%	

IPD: intra-prosthetic dislocation; NOT: non-operative treatment.

Table 2
Case-series studies of revision surgery with dual-mobility cup implantation for recurrent dislocation.

Authors	*N*	Follow-up	Dislocation	Loosening
Leclercq et al. [27]	13	?	7.7%	
Guyen et al. [17]	54	4 years (2.2–6)	1.9% (NOT) IPD: 3.8%	Cage screw breakage: 1
Leiber-Wackenheim et al. [18]	59	8 years (6–11)	1.7% (NOT)	0%
Hailer et al. [19]	228	2 years (0–6)	Revision: 1.7%	No revision? Revision: 1.7%
Mertl et al. [20]	180	7.7 years (4–14)	4.8% RD: 1.4% Revision: 0.7% IPD: 1.4%	Revision: 1.4% No revision: 1.4%
Saragaglia et al. [21]	29	46 ± 28 months (17–132)	3.4% (NOT)	
Jakobson et al. [22]	56	44 months (0.1–119)	1.8% IPD: 1.8%	Revision: 1.8%
Van Heumen et al. [29]	50	29 months (12–66)	0%	2%
Mohaddes et al. [24]	436 versus 355 other techniques	3.1 ± 2.4 years		Revision: 1.6% versus 6.8%
Stucinskas et al. [25]	247 versus 115 other techniques	2 ± 1 years (0–5)		Revision: 2% versus 9%
Hamadouche et al. [26]	51	8.5 years (5–13)	Revision: 2% IPD: 3.9%	3.9%

IPD: intra-prosthetic dislocation; RD: recurrent dislocation; NOT: non-operative treatment.

Table 3
Patient-related risk factors.

	Cases (*n* = 16)	Controls (*n* = 48)	Univariate analysis: *p* value	Multivariate analysis
BMI > 30	6 (37.5%)	5 (10.4%)	0.022	–
ASA Score [28]	2.3 (1–3)	2.2 (1–3)	0.53	–
Reason for THA	Primary hip OA: 12 Secondary hip OA: 3 Metastasis: 1	Primary hip OA: 38 Secondary hip OA: 10	0.73	–
Side	R: 8; L: 8	R: 26; L: 22	0.78	–

ASA: American Society of Anesthesiologists; BMI: body mass index; NS: non-significant; OA: osteoarthritis; R: right; L: left.

Of the 16 cases, 1 was lost to follow-up, 1 had contra-indications to anaesthesia that precluded further surgery, and 1 died 21 months after ReDMC after experiencing several episodes of dislocation. In 5 (31.3%) of the 16 cases, reduction was not followed by any further dislocation episodes after a mean follow-up of 20 ± 18 months (range, 2–54 months) (Fig. 1). The remaining 8 patients underwent the following surgical procedures: surgical reduction ($n = 1$; this patient died 3 months later without experiencing further dislocations); implantation of a Lefèvre constrained cup ($n = 3$, including 1 who underwent trochanteric internal fixation, with no further dislocations after a mean follow-up of 87.3 ± 32,8 months (range, 41–111 months) (Fig. 2); trochanteric internal (Fig. 3) fixation ($n = 1$, with no further dislocations after 3 months); and repeat revision arthroplasty ($n = 3$: cup exchange with reorientation of the new cup ($n = 1$), followed by 5 dislocation episodes during the next 43 months; exchange of both components ($n = 1$), with no further dislocation episodes during the 2-month follow-up; and exchane of the femoral component ($n = 1$), followed by further disclocations during the nect 6 months). Thus, in all, 4 cases underwent implantation of a constrained cup. None of these patients experienced further dislocation episodes over a mean follow-up of 67.0 ± 45.2 months (range, 6–111 months).

Table 4
Risk factors related to the local history.

	Cases. $n = 16$	Controls. $n = 48$	Univariate analysis. p value	Multivariate analysis, OR [95%CI]
N of surgical procedures	2.8 (1–6)	1.8 (1–5)	0.009	
Number of prosthetic procedures	2.3 (1–4)	1.5 (1–4)	0.004	
Reason for revision	Acetabular loosening: 9 Bipolar loosening: 3 Recurrent dislocation: 2 Chronic dislocation: 5 * isolated: 2 * + acetabular loosening: 3	Acetabular loosening: 35 Bipolar loosening: 10 Recurrent dislocation: 3 Chronic dislocation: *isolated: 0 * + acetabular loosening: 2	0.13	
Pre-operative instability	Recurrent dislocation: 2 Chronic dislocation: 5	Recurrent dislocation: 3 Chronic dislocation: 2	0.004	14.5 [1.5–142.9]
Acetabular bone loss (Paprosky)[29]	1: 1 2: 11 (A: 3; B: 3; C: 5) 3: 4 (A: 3; B: 1 + fracture)	1:4 2:40 (A: 16; B: 8; C: 16) 3:4 (A: 1;B: 3)	0.14	
Femoral bone loss (Paprosky) [30]	1: 4 2: 4 3A: 5 3B: 1 4: 2		1:21 2:13 3A:8 3B: 4 4: 2	0.39
Impaired abductor apparatus	GT non-union: 7 No GT: 1 Gluteus medius and minimus tears: 1	GT non-union: 7	0.002	43.14 [3.18–586.3]

GT: greater trochanter; OR: odds ratio; 95%CI: 95% confidence interval.

Table 5
Risk factors for dislocation related to the revision procedure.

	Cases. $n = 16$	Controls. $n = 48$	Univariate analysis. p value	Multivariate analysis, OR [95%CI]
Approach	Posterior: 9 Extended trochanteric osteotomy: 4 GT non-union: 2 Antero-lateral: 1	Posterior: 30 Extended trochanteric osteotomy: 12 GT non-union: 3 Antero-lateral: 3	0.9	–
Acetabular Reconstruction	Kerboull device/Allograft: 12 TM: 3 Custom-made cementless cup: 1 Cemented DMC: 1	Kerboull device/Allograft: 40 Burch cage/Allograft: 2 TM (cup and augment): 6	0.64	–
Cup diameter	49.3 (46–56) mm	49.1 (46–56) mm	0.68	–
Head diameter	22mm: 13 28mm: 3	22mm: 38 28mm: 10	0.87	–
Cup inclination	44.1° (25–61)	41.2° (31–66)	0.38	–
Femoral offset	44.8 (31–57) mm	47.9 (34–64) mm	0.24	–
Final LL length	− 5 (− 14 ± 29) mm	− 1.1 (− 31–16) mm	0.39	–

GT: greater trochanter; TM: trabecular metal; DMC: dual-mobility cup; LL: lower limb.

Fig. 1. A. Aseptic acetabular loosening Paprosky IIIA and femoral IIIB. B. Bipolar revision with trabecular metal cup and superior augment; cementless locked revision stem. C. Dislocation after 2 months, with no recurrence 2 years after closed reduction.

4. Discussion

Our study meets our first objective by showing a dislocation rate similar to that reported in most former studies of revision THA (Tables 1 and 2), in which dislocation also usually occurred early, within the first 18 months. Thus, the use of a DMC does not guarantee definitive stability after revision surgery. The strongest predictor of dislocation was abductor apparatus compromise, followed by a history of prosthetic hip instability. Previous studies identified the same risk factors as those found in our population, including abductor apparatus compromise [8,9,11,15,20,27], a history of prosthetic hip instability [8,9], and two or more previous surgical procedures on the hip [8,19,20]). Other risk factors have also been reported such as rheumatoid arthritis as the reason for THA [5], infection as the reason for revision surgery [2,8], and technical errors ReDMC [11,27] including implant malposition and inadequate or absent abductor apparatus repair. Wegzryn et al. [11] emphasised the importance of these two technical errors and recommended performing CT to look for implant malposition in

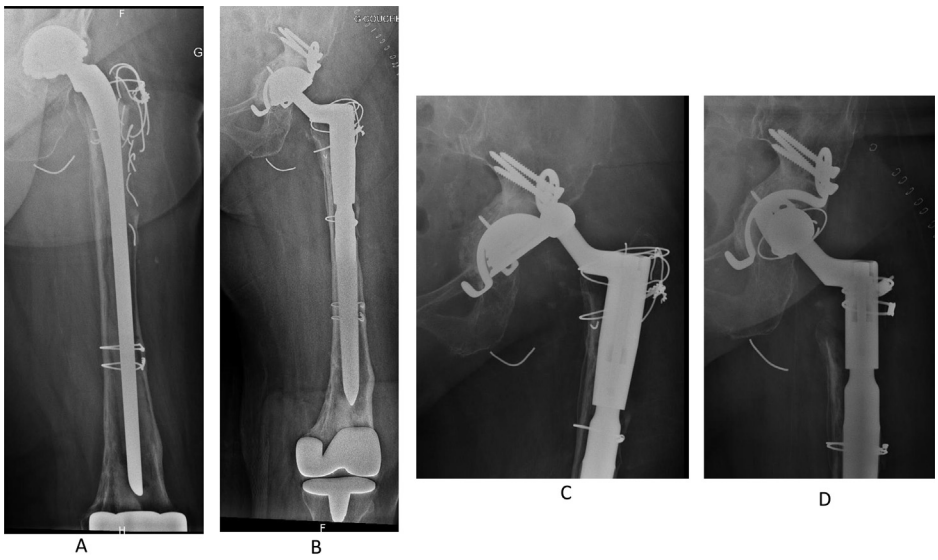

Fig. 2. A. Aseptic acetabular loosening Paprosky IIC and femoral IIIB. B. Bipolar revision with acetabular reconstruction using an allograft and Kerboull reinforcement ring; long modular cementless stem. C. Early recurrent dislocations. D. Lefèvre constrained cup with greater anteversion.

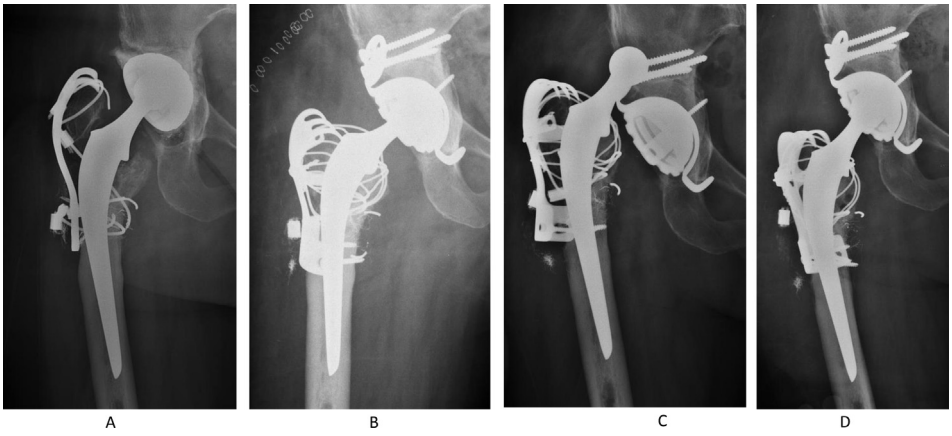

Fig. 3. A. Acetabular loosening Paprosky IIA with non-union of the greater trochanter. B. Acetabular revision using an allograft and Kerboull reinforcement cage; internal fixation of the greater trochanter using circling wires and a claw-plate. C. Hook migration, recurrent non-union and dislocation after 8 months. D. Stabilisation by repeat trochanteric internal fixation.

patients with a subsequent dislocation episode. A DMC cannot prevent dislocation in patients with implant malposition. These risk factors for dislocation apply also to conventional cups.

Describing the outcomes of treatments for dislocation after ReDMC was our second objective. Some patients experienced no further dislocation episodes after non-operative reduction, in keeping with previous data (Tables 1 and 2). In patients with recurrent dislocation, the treatment consisted either in correcting malposition of the cup and/or stem and/or in implanting a Lefèvre constrained cup. In addition, abductor apparatus reconstruction was performed whenever possible. In other studies also, further surgery was required to stabilise the hip, but neither the nature nor the outcomes of the procedures were reported [19,26]. According to Stucinskas et al. [25], soft-tissue tensioning by changing the femoral head to lengthen the neck produced mediocre outcomes. In patients with abductor apparatus impairment, Mertl et al. [20] advocated repair and/or a constrained cup and Wegzryn et al. [11] a constrained cup. Hernigou et al. [31] suggested the following strategy. In patients with malposition but no CT evidence of fatty degeneration of abductor apparatus, a new DMC should be implanted. It may be helpful to choose a DMC of a larger diameter if the bone stock is sufficient and no impingement on the ilio-psoas tendon occurs. In patients with muscle wasting or degeneration, or with absent muscles, a constrained cup is the safest option [31]. These authors chose the Lefèvre constrained cup, which has been shown by Clavé et al. [32] to produce better outcomes compared to constrained cups from North-American companies [33]. Nevertheless, no independent studies exist to verify the findings reported by the designers. We have no experience with large-diameter femoral heads, which have been associated with trunnionosis [34] but are still used with a metal-polyethylene bearing couple. Van Sikes et al. [35] reported that a head diameter greater than 36 mm was effective in treating hip prosthesis instability, except when the abductor apparatus was compromised. Hartzler et al. [36] compared the 7-year outcomes of 146 ReDMC procedures and 209 revisions with a 40-mm head and reported dislocation rates of 3% vs. 10% and re-revision rates of 1% vs. 6%, respectively.

Our study has several limitations. The design was retrospective, but the groups were homogeneous since the reason for THA was osteoarthritis in all patients. The surgical approaches and revision techniques varied widely across patients, but a single DMC design was used. Some cases of dislocation may have escaped notice, particularly when there was a single episode. CT was performed in only 9 of the 16 cases and in none of the 48 controls. Nevertheless,

these limitations do not affect our findings, given the strict matching of cases and controls. On the other hand, potential effects of the matching criteria could not be assessed. Age between 45 and 55 years was a risk factor for dislocation in one study [19]. Revision of the acetabulum only is not a risk factor for true dislocation but increases the risk of intra-prosthetic dislocation if the preserved femoral component does not have a smooth, polished, and slender neck [11,17,20,25]. Spinal abnormalities (e.g., lumbar fusion) are known to increase the risk of dislocation after primary THA, but were absent in our population and consequently could not be assessed. The three main limitations to our evaluation of treatment outcomes are the very small sample size, the use of a variety of treatment modalities, and the short follow-up. Our findings are in agreement with others [2,11,14,15,17,18,21], however, in establishing that revision surgery is not consistently required.

5. Conclusion

The considerable efficacy of DMCs in preventing hip prosthesis instability after revision surgery can be jeopardised if the abductor apparatus function is impaired. Consequently, CT should be performed to assess the gluteus medius and minimus muscles [31]. If abductor apparatus can be improved, then a DMC is sufficient to prevent instability in the vast majority of cases. Otherwise, a Lefèvre constrained cemented cup deserves consideration, notably in patients who also have other risk factors for instability. Preservation of the abductor apparatus during primary and revision THA is therefore the best means of preventing or treating hip prosthesis instability.

Disclosure of interest

The authors declare that they have no competing interest.

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Contributions

D. Huten conceived the study, wrote the manuscript, and performed the requested revisions.

Y. Fournier identified the cases, set up the case-control study, called and re-evaluated the patients, entered the study data into an Excel spreadsheet, and handled interactions with the clinical investigation centre of the Rennes university hospital.

T. Gicquel contributed to write the manuscript and prepared the illustrations.

P. Bertho identified all the revision procedures performed at our department during the study period, with or without a dual-mobility cup, and contributed to identify the cases.

M. Hamadouche revised and corrected the manuscript.

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