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Original article

Dual mobility cups in total hip arthroplasty after failed internal fixation of proximal femoral fractures

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ABSTRACT

Introduction: Performing total hip arthroplasty (THA) following failed internal fixation of proximal femur fractures is associated with an elevated risk of implant dislocation. We hypothesized that using a dual mobility (DM) cup will help to reduce the risk of postoperative instability in this specific context.
Material and methods: This was a retrospective study of 33 consecutive patients who underwent DM THA following failed internal fixation of a proximal femur fracture. The clinical assessment consisted of the Postel-Merle d'Aubigné and HHS scores along with an analysis of preoperative and follow-up radiographs. The primary outcome was the occurrence of implant dislocation.
Results: At the last follow-up (44 ± 24 months), 7 patients had died and 0 were lost to follow-up. Only one dislocation had occurred (3%). The mean PMA and HSS scores of 14.8 and 80 respectively were significantly better than the preoperative scores. There were no cases of aseptic loosening.
Conclusion: The use of DM cups in the context of THA following failed internal fixation of proximal femur fractures helps to reduce the risk of dislocation. Thus DM cups are recommended in this indication with high risk of postoperative instability.

1. Introduction

The failure rate of internal fixation for proximal femur fractures is 20% to 30% [1]. In this context, recourse to total hip arthroplasty (THA) is often the case. However, there are technical difficulties inherent to this procedure, especially in cases of extracapsular fractures. The need to remove the fixation hardware, the potential presence of malunion and the modified anatomical landmarks can lead to errors in implant positioning. Periprosthetic muscular weakness related to repeat procedures increases the risk of postoperative complications and especially that of implant dislocation [2–4]. In this indication, the postoperative instability rate of about 10% is significantly higher than following primary THA [5–7].

By reusing the McKee concept, dual mobility (DM) cups help to increase the jump distance and thereby reduce the risk of implant dislocation [8,9]. For 30 years, the design has been shown to be effective at preventing postoperative instability following primary THA and revision THA procedures [4,10–14]. Recent comparative studies have confirmed DM cups are better than standard cups at preventing implant dislocation [15,16]. Nevertheless, there are few studies on the outcomes of DM cups during revision for failed internal fixation of the proximal femur. Only Muller et al. have reported results of THA with a DM cup in this indication [17]. However, DM cups were used in only 6% of their cases.

We hypothesized that using DM cups in this specific context would reduce the risk of postoperative instability. The objective was to evaluate the implant dislocation rate after DM THA following failed internal fixation of a proximal femur fracture.

2. Materials and methods

2.1. Study population

This was a continuous, single center, retrospective study. All patients who underwent THA with a DM cup following failed internal fixation of a proximal femur fracture between May 2010 and December 2014 were included. Patients were excluded if they had suffered an infection after the initial fracture fixation procedure. Surgical revision by THA following failed internal fixation of a proximal femur fracture was indicated for symptomatic nonunion,

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Table 1
Characteristics of study population.

	Number (%)
Mean age	74
Sex	
Female	29 (87.7%)
Male	4 (12.2%)
Initial fracture	
Trochanteric	22 (66.6%)
Femoral neck	8 (24.2%)
Base of femoral neck	3 (9%)
Initial fixation	
Gamma nail	23 (69.6%)
Cannulated screw	6 (18.2%)
DHS	4 (12.1%)
Indication for reoperation	
Hardware migration	16 (48.5%)
Osteonecrosis	9 (27.3%)
Nonunion	6 (18.2%)
Malunion	2 (6%)

avascular necrosis, poorly tolerated malunion or secondary migration of the fixation hardware (Table 1).

In all, 33 patients (4 men, 29 women) were included. Their mean age at time of surgery was 74 years ± 15 [27–96]. Their mean BMI was 25 ± 4.8 [18.78–38.09]. The initial indication was a pertrochanteric fracture (n = 22, 67%), femoral neck fracture (n = 8, 24%) or base of femoral neck fracture (n = 3, 9%). The initial internal fixation procedure consisted of the implantation of a dynamic nail (n = 23, 70%), screw plate (n = 4, 12%) or cannulated screw (n = 6, 18%) (Table 1).

2.2. Surgical technique and implants used

Single-stage surgery, combining hardware removal and DM THA implantation by the posterolateral approach was completed. The DM cups were from the NOVAE® product line (SERF®[1]). These are third-generation cups, forged in 316 L stainless steel with a bilayer coating of plasma-sprayed titanium and hydroxyapatite. Depending on the bone quality and size of bone defect observed intraoperatively, two types of cups were used. The cases with satisfactory bone stock received a cup with press-fit fixation (NOVAE® SUNFIT TH) (Fig. 1). In the cases where the bone defect did not allow for adequate primary stability, a tripod cup (press-fit fixation with 2 pegs and 1 proximal flange) was used (NOVAE® E TH).

The femoral stems used (TSF®[2], Corail®[3], Louxor®[4]) were either cementless or cemented, depending on the quality and quantity of femoral bone stock after removal of the fixation hardware.

The femoral heads were made of 316 L stainless steel or cobalt-chrome alloy and were 22.2 mm or 28 mm in diameter. The 28 mm diameter heads were only implanted with cups sized 53 or larger, to ensure the polyethylene liner was at least 10 mm thick, in accordance with the manufacturer's recommendations.

2.3. Clinical and radiological assessments

The clinical and radiological follow-ups were carried out at 45 days, 3 months, 6 months, 1 year, then every 2 years until the final follow-up. The patients' general condition was evaluated using the Charlson score and the American Society of Anesthesiologists (ASA) score [18–20]. The clinical outcomes were determined using the Postel-Merle d'Aubigné (PMA) score and the Harris Hip Score (HHS) [21,22]. The duration of the surgical procedure was recorded. The radiological analysis was done with OSIRIX® software[5] to look for periprosthetic osteolysis, to determine the change in cup inclination between the immediate postoperative period and last follow-up, and to calculate the ARA score [23] and Brooker score [24]. All of the complications, such as dislocation, infection, loosening, and periprosthetic fractures were recorded.

2.4. Statistical analysis

The primary outcome was the occurrence of a dislocation. Student's t-test, the Chi^2 test and analysis of variance were used to analyze the distribution of quantitative variables, qualitative variables and variability factors. The statistical analysis was done using R®[6] software. The significance threshold was set at $p < 0.05$.

3. Results

3.1. Population and implants

The mean postoperative follow-up was 44 ± 24 months [2–83 months]. At the latest follow-up, 7 patients (21%) had died for reasons unrelated to the surgery and 0 patients were lost to follow-up. Preoperatively, the mean Charlson score was 2.28 ± 2.5 [0–11], with 9 patients ASA 1, 11 patients ASA 2 and 13 patients ASA 3. The mean time between internal fracture fixation and the surgical revision was 5 ± 6 months [0–22]. The mean operative time was 100 ± 34 min [60–209]. The press-fit NOVAE SUNFIT® TH cup was used in 18 patients (55%), while the NOVAE E® TH tripod cup was used in 15 patients (45%). The 22.2 mm diameter head was used in most cases (n = 31, 94%). On the femur side, 28 cementless stems (84%) and 5 cemented stems (15%) were used.

3.2. Clinical and radiological assessments

The PMA and HHS scores significantly improved between the preoperative period and the latest follow-up visit, going from 6.3 ± 2.8 [3–15] to 14.8 ± 2.6 [9–18] ($p < 0.001$) and from 30.27 ± 15.7 [5–7] to 80 ± 13.8 [50–100] ($p < 0.001$) (Table 2), respectively. There were no significant differences between the preoperative scores of the three fixation method subgroups (Table 2).

At the latest follow-up, the mean ARA score was 5.4 ± 0.8 [4–6] and the mean Brooker score was 2 ± 1 [1–4]. Two patients had acetabular osteolysis in Gruen zone I while two patients had acetabular osteolysis in Gruen zone II. There were no cases of septic or aseptic loosening. There was no significant change in cup inclination, which went from 47 ± 8° [32–60] in the immediate postoperative period to 47 ± 8° [33–61] at the latest follow-up (p = 0.2).

3.3. Complications

Unfortunately, there were 6 intraoperative femur fractures: one metaphysis and diaphysis junction fracture require plate fixation and 5 greater trochanter fractures required wire cerclage.

Two early postoperative complications required surgical revision: one dislocation and one infection. The dislocation occurred early on after a fall and was considered post-traumatic. Open reduction was needed because closed reduction maneuvers failed. Thus

[1] SERF®, Décines-Charpieu, France.
[2] SERF®, Décines-Charpieu, France.
[3] DePuy-Synthes, Warsaw, IN, USA.
[4] SEM, Créteil, France.
[5] Pixmeo SARL, 266, rue de Bernex, CH-1233 Bernex, Switzerland.
[6] R Core Team.

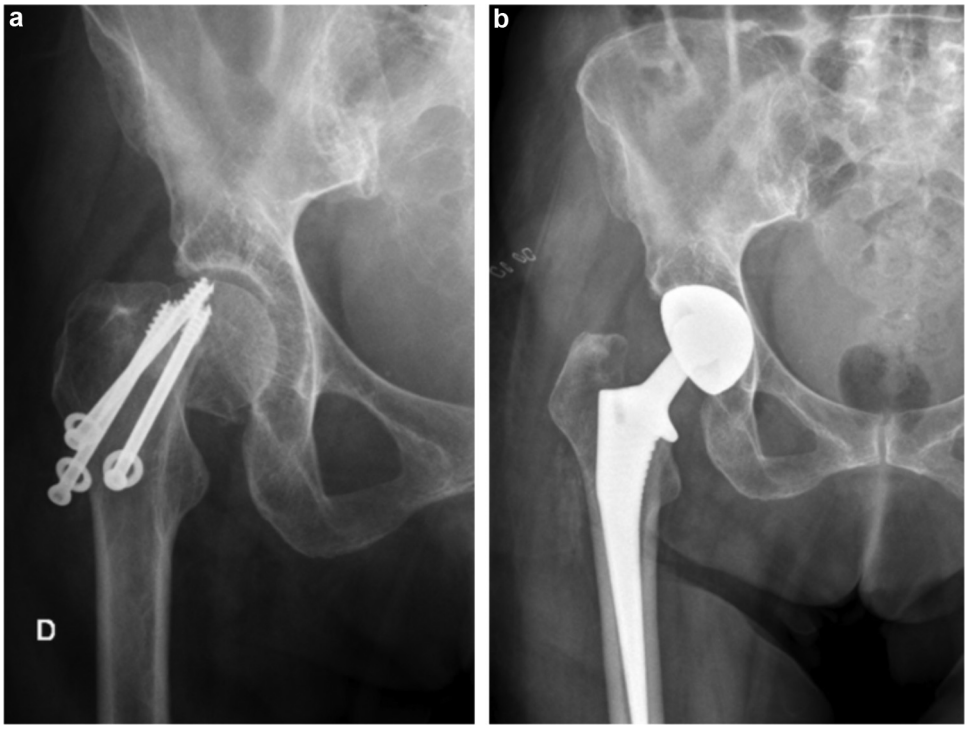

Fig. 1. a: failure of internal fixation of a right femoral neck fracture; b: X-rays at 4 years' after the surgical revision by THA with DM cup (right leg).

Table 2
Characteristics of the various internal fixation subgroups.

	Nail($n=23$)	Screw fixation($n=6$)	DHS($n=4$)	p-value
Mean age	74	72	70	0.73
Gender				
Female	21	5	3	
Male	2	1	1	
Mean Charlson score	2	3	3	0.82
Preoperative Harris Hip Score, (mean)	28.3 ± 15.6	35.5 ± 20	33.25 ± 9	0.58
Preoperative PMA score, (mean)	6.2 ± 2.7	7 ± 4	5.5 ± 1	0.71
Mortality, (%)	17.3	16.6	50	0.34

as the last follow-up, the overall dislocation rate was 3%. The infection was deep and occurred early on. This patient was treated with a DAIR (debridement, antibiotics and implant retention) procedure; the infection healed and there was no recurrence at the last follow-up.

All of the intraoperative and postoperative complications occurred in patients who had initially been treated with a Gamma® Locking Nail (Stryker) for their femur fracture.

4. Discussion

Our hypothesis is confirmed. Use of a DM cup in THA surgical revision of failed internal fixation of proximal femur fracture results in a low implant dislocation rate.

The first important finding is the high complication rate associated with THA procedures in this specific indication. With an overall complication rate of 21% ($n=7$), our study falls at the upper end of published rates. In a meta-analysis, Mahmoud et al. reported a mean complication rate of 12% [7]. Only the studies by Müller et al. [17] (21% rate) and Dehaan et al. [25] (26% rate) found higher complication rates than in our study. The complication rate of revision THA after failed fracture fixation is significantly higher than following primary THA. Nilsson et al. [26] along with Oztürkmen et al. [27] found a 17% complication rate for revision THA versus 13% for primary THA in cases of proximal femur fracture. This higher rate can be explained by the technical difficulties encountered during revision surgery. Removal of the fixation hardware, muscle atrophy, reduced bone stock, leg length difference, or presence of malunion can modify the skeletal architecture and make it more difficult to position the implant. These factors contribute to the technical difficulty of THA revision with risk of intraoperative and postoperative complications.

The second important finding is that only patients with pertrochanteric fractures who underwent intramedullary nailing initially suffered a complication after revision THA. No complications were found in the patients who had a femoral neck fracture or base of femoral neck fracture. Thus there is a legitimate difference between intracapsular and extracapsular fractures. This observation is consistent with published results. The Tetsunaga et al. [28] study of 50 patients also found complications only in the subset of patients with pertrochanteric fractures. Mehloff et al. [29] reported three cases of implant dislocation in the subgroup who had suffered a pertrochanteric fracture ($n=13$) but no complications in the subgroup who had suffered a femoral neck fracture ($n=14$). In our study, the large proportion of patients with a pertrochanteric fracture (66.6%) may explain our high complication rate.

One aspect that may explain these differences between fracture types is the greater complexity of the revision surgery procedure for pertrochanteric fractures. Revision of extracapsular

Table 3
Summary of relevant published studies.

Study	Number of patients	Initial fixation	Mortality rate (%)	Implants Standard cup: STD Dual mobility: DM	Approach	Dislocation rate (%)	Complication rate (%)	Revision surgery (%)
Mahmoud et al. (2016) [7]	168	-	-	-	-	7	12	-
McKinley et al. (2002) [2]	107	Screw	23	STD (Charnley prosthesis)	Posterior	19.6	44	-
Archibeck et al. (2013) [30]	102	Nail 3 Screw 42 Screw/plate 57	44.1	STD (Zimmer®)	-	4.9	11	6.8
Mortazavi et al. (2012) [31]	154	DHS 61 Nail 10 Screw 83	4.5	STD (Stryker®. Biomet®)	Lateral	0	9	5.8
Enocson et al. (2012) [32]	88	Nail 55 DHS 30 Screw/plate 3	16	STD (Stryker®. Zimmer®. DePuy®)	Hardinge 53 Moore 35	3.4	15.9	16
Franzén et al. (1990) [6]	84	-	50	STD (Link®)	Posterior	4.7	9.5	-
Muller et al. (2017) [17]	80	DHS 50 Nail 26 Screw 4	28	STD 93.7% DM 6.3% (Zimmer®)	Lateral	1.2	16.2	21
Tetsunaga et al. (2017) [28]	50	Screw 15 Nail 17 DHS 9	-	STD (DePuy®. Zimmer®. Kyocera®)	Hardinge 38 Posterolateral 11 Watson-Jones 1	4	14	-
Dehaan et al. (2013) [25]	46	Nail 16 Screw/plate 30	-	STD	-	6.5	26	13
Haidukewych et al. (2003) [33]	32	Screw/plate	31.25	-	-	3.1	15	15.6
Winemaker et al. (2006) [34]	36	Screw/plate 22	0	STD	-	0	13	5.5
Hammad et al. (2008) [35]	32	-	18.7	STD	-	3.1	6.2	-
Shi et al. (2015) [36]	31	DHS 17 Nail 8 Plate 6	9.6	STD	Posterolateral	6.4	22	-
Our study	33	Nail 23 DHS 4 Screw 6	21	DM (Serf®)	Moore	3	21	3

fractures are more difficult technically and have a higher risk of complications. In these fractures, due to the appearance of malunion or even nonunion, all of the anatomical landmarks are modified, which complicates implant positioning. In addition, nail removal is an invasive surgical procedure that can lead to heterotopic ossification and lesions of the gluteus medius, which are known to contribute to instability.

Given these challenges, the use of DM cups seems relevant. Even if they do not eliminate all the complications inherent to this type of surgery, they reduce the risk of dislocation relative to THA studies using standard cups (Table 3). An analysis of the literature shows the dislocation rate with standard (non-DM) cups ranges from 0% to 20%: 3.1% for Hammad et al. [35], 4.9% for Archibeck et al. [30], 6.4% for Shi et al. [36] and 19.6% for McKinley et al. [2]. With a 3% dislocation rate, our study of revision THA with DM cups falls in the lower end of this range. It has been shown that DM cups are effective at reducing the dislocation risk even in patients with major deficits in their hip abductors [37,38]. With a majority of cases in our study involving an extracapsular fracture, this insufficiency of the gluteus medius is likely largely present in our study. Nevertheless, we only found one case of dislocation. By reducing the risk of postoperative instability, DM cups appear to be a relevant treatment options when performing THA after failed proximal femur fracture fixation.

Our study has several limitations. The moderate size of the cohort contributed to reducing the statistical power of our analysis. Nevertheless, given the low incidence of this surgical indication, our study is comparable in terms of sample size to other published studies on this topic [33,34]. The lack of homogeneity of the various groups also makes the subgroup analysis difficult to interpret. Lastly, while the mean follow-up was relatively short, it was comparable to that of other published studies (between 1 and 7 years) [7,14,32].

5. Conclusion

Use of DM cups in the context of THA after failed internal fixation of proximal femur fractures helps to reduce the risk of implant dislocation. Thus its use can be recommended in this indication with high risk of postoperative instability.

Disclosure of interest

The authors declare that they have no competing interest.

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None.

Contribution

Sandrine Boulat and Thomas Neri helped to collect data and write the manuscript.

Bertrand Boyer provided critical review of the manuscript.

Rémi Philippot and Frédéric Farizon supervised the study and provided critical review of the manuscript.

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