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Original research

# OUTCOMES OF DUAL - MOBILITY CUP FOR DISPLACED FEMORAL NECK FRACTURES IN THE ELDERLY

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### ABSTRACT

**Background:** Femoral neck fracture (FNF) is a common intracapsular fracture in the elderly as a result of osteoporosis, which tends to increase with humans' extended longevity. Regarding treatment for undisplaced FNF, internal fixation is mostly used, while primary total hip arthroplasty (THA) is used for older patients with displaced FNF because of the high rate of avascular necrosis and nonunion. THA shows a better functional result than internal fixation in treating FNF; however, dislocation is still a severe complication. Recently, the dual mobility cup (DMC) has become more and more popular as a solution to reduce dislocation. The purpose of this research is to evaluate the outcome of dual-mobility cups for FNF in the elderly.

**Methods:** A retrospective study was carried out on 164 patients who had THA by means of a dual mobility cup and posterolateral approach in Hue Central Hospital from January 2018 to April 2023. Medical history, clinical and paraclinical features, and the modified Harris Hip Score (MHHS) were assessed. TraumaCad® software was used to measure the figures of hip prostheses.

**Results:** One hundred and sixty-four patients with a mean age of seventy-five years were followed up from 6 to 64 months. More than 90% of patients had osteopenia and osteoporosis according to bone mineral density. The average figures include length of incision (7,4 cm), operation duration (66,4 minutes), blood loss volume (664,6 ml), discrepancy of leg length under 10mm (97%); size of prothesis: shell (49,1mm), stem (11,6mm), head with short neck (90,2%). Radiological assessment showed that the mean abduction angle and anteversion angle were  $48,1^{\circ} \pm 5,4^{\circ}$  and  $20.1^{\circ} \pm 5,6^{\circ}$  respectively. There were four intraoperative calcar fractures (2,4%), three periprosthetic fractures (1,8%), no hip dislocation, no aseptic loosening and no infection. The overall MHHS was  $92,1 \pm 7$ .

**Conclusion:** DMC is an alternative option to prevent dislocation and give good outcomes to elderly patients with FNF. Longer follow-up duration may have revealed complications of DMC.

**Keyword:** Femoral neck fracture, dual mobility cup, total hip arthroplasty, American Society of Anesthesiology, modified Harris Hip Score.

### **I. INTRODUCTION**

FNF is an intracapsular fracture that commonly occurs in the elderly population due to osteoporosis. The average life expectancy of the population is increasing, leading to an upward trend in the incidence of hip fractures, estimated increase from 1.66 million people (1990) to 6.26 million people (2050) [1, 2].

Regarding the displaced FNF in the elderly, THA is increasingly being used in treatment compared to

internal fixation having more risk of revision due to complications, such as pseudoarthrosis or avascular necrosis of the femoral head [3, 4]. Although hemiarthroplasty has a lower dislocation rate and shorter surgical time, it is usually used for patients with low active demand or accompanying severe comorbidities due to an early complication such as acetabular wear causing pain [5]. THA overcomes these limitations and provides better hip function

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compared to hemiarthroplasty, although it has a longer surgical time, higher blood loss, and higher rate of post-operative dislocation [6, 7]. According to a study by Iorio et al. (2001) [8] in elderly patients with FNF, the dislocation rates for total hip replacement and hemiarthroplasty were 10.7% and 2.9% respectively.

Therefore, DMC is considered as an alternative solution to standard hip prostheses in order to reduce the risk of dislocation in patients undergoing total hip replacement. According to a study by Adam et al. (2012) [9] on 214 patients with FNF, the dislocation rate of the DMC was 1.4% after a 9-month follow-up. In a study by Tarasevicius et al. (2010) [10] on the treatment of FNF using posterior approach, the dislocation rates for the dual mobility hip joint and conventional prosthesis were 0% and 14.3% respectively. This implant's stability comes from its unique design. The implant consists of two articulations, one which is not constrained between the acetabular cup and the mobile polyethylene liner, while the other is constrained between the femoral head and the mobile polyethylene liner.

The DMC was first used in France in 1977 and later widely adopted in Europe, but it was not until 2004 that it was approved for use by the U.S. Food and Drug Administration [11, 12]. Since 2015, the dual mobility hip joint has been utilized in total hip replacement surgeries at Hue Central Hospital in Vietnam. However, the surgical outcomes of dual mobility hip replacement in patients with hip fractures have not been fully evaluated. For these reasons, we conducted this research to evaluate the outcomes of total hip replacement using DMC in the treatment of elderly patients with FNF.

## **II. PATIENTS AND METHODS**

### 2.1. Patients

This retrospective and non-comparative study was conducted on 164 patients (110 women, 54 men) who had THA of dual mobility cups in Hue Central Hospital from January 2018 to April 2023. Those chosen for this research were the elderly aged 60 and above having normal mobility before suffering the displaced FNF which is classified as Garden III - IV. The exclusion criteria include: pathological fractures of the femoral neck, acetabular reinforcement and hip arthroplasty after failure of internal fixation, associated fractures in the same leg with FNF, surgical risk by the American Society of Anesthesiology (ASA) from grade IV or higher, abnormal mobility before suffering the trauma.

### 2.2. Surgery

The same standardized surgical technique via a posterolateral approach was used for all patients. The cut level is calculated preoperatively by digital radiographs:  $d = d_1 + d_2$  (Figure 1).

d: distance from center of rotation to lesser trochanter in normal femur.

d<sub>1</sub>: femoral neck cut level (mostly 5mm)

 $d_2$ : length of femoral neck implant (only available in 45mm)



Figure 1: (a) preoperative X-Ray showing the position of femoral neck cut in normal femur and (b) postoperative X-ray with a DMC.

Soft tissues were repaired at the end of the operation. Second-generation cephalosporin antibiotic prophylaxis was performed 30 minutes before surgery and post-operative time. Enoxaparin by subcutaneous injection was used for prophylaxis of phlebitis during the hospitalization, while Rivarixaban was carried

out by oral for a period of 30 days postoperatively. All patients received the same rehabilitation program and weight-bearing immediately after surgery except in the event of intraoperative complications.

In this study, implants of Groupe Lépine including Quattro<sup>TM</sup> Vps Hap Cup PnP and Pavi<sup>TM</sup> Hap Stem 135° was used (Figure 2.). Cobalt chrome heads of 22 mm diameter were used for 44 mm and 46 mm diameter cups and 28 mm heads were used for 48 mm and more. The size of Polyethylene liner depended on the size of its cup and head.



**Figure 2:** Quattro<sup>™</sup> Vps Hap Cup PnP and Pavi<sup>™</sup> Hap Stem (Groupe Lépine) **2.3. Data collection and statistical analysis** 

The following intraoperative figures were collected: operation duration, length of incision, intraoperative complications, size of hip prosthesis. The postoperative parameters were gathered: estimation of blood loss volume (EBLV), 3 - day postoperative pain by Visual Analog Scale (VAS), discrepancy of leg length (DLL), postoperative complications and the position of DMC. TraumaCad® software is used to measure the anteversion and inclination angle of the cup, angle of femoral stem and DLL. Our research evaluated the hip function of patients based on a THA by MHHS. SPSS 26 software was used for the analysis.





Figure 3: Evaluating the position of total hip prosthesis by TraumaCad® software

## **III. RESULTS**

164 patients were included in the study with 6 - 64 follow-up months (Table 1). The mean age was 75.2 years  $\pm 8.1$  (60 - 91), with 67.1% of patients were females. At the last follow-up, 32 patients (19.5%) had died. **Table 1:** General information about patients:

	# of patients n = 164
Age (years)	75.2 ± 8.1 (60 - 91)
Sex (male/female)	110/54
Side	
- Right	97 (59.1%)
- Left	67 (40.9%)
Mechanism of injury: falling	164 (100%)
Associated injuries:	
- Distal radial fracture	3 (1.8%)
- Proximal humeral fracture	1 (0.6%)
Death (%)	32 (19.5%)
BMI (kg/m <sup>2</sup> )	21.6 ± 2.5 (16.5 - 27.1)
ASA	
- Grade I	33 (20.1%)
- Grade II	70 (42.7%)
- Grade III	61 (37.2%)
Accompanying disease	
- Cardiovascular diseases	76 (46.3%)
- Endocrine diseases	42 (25.6%)
- Schizophrenia	3 (1.8%)
- Parkinson's syndrome	5 (3.0%)
- Other	38 (23.2%)
- No accompanying disease	33 (20.1%)
Bone mineral density at femoral neck (T-score)	
- Normal	$-2.4 \pm 1.1 (-4.5 - 0.1)$
- Osteonenia	14 (8.5%)
- Osteoporosis	68 (41.5%)
- 03000010313	82 (50.0%)

Approximately half of patients had cardiovascular diseases (46.3%), while schizophrenia and Parkinson's syndrome were found in 3 and 5 patients, respectively. 91.5% of our patients had an abnormal index for bone mineral density.

The average operation time was 66.4 minutes  $\pm$  12.5 (45 - 100), average length of incision was 7.4 cm  $\pm$  0.6 (6 - 9). Mean EBLV during the operation was 664.6 mL  $\pm$  456.5, needed blood-transfusion was n = 50 (30.5%). Mean hospitalization time was 11.7 days  $\pm$  2.5 (Table 2).

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	n = 164
Operation time (minutes)	$66.4 \pm 12.5 (45 - 100)$
Length of incision (cm)	$7.4 \text{ cm} \pm 0.6 (6 - 9)$
EBLV (ml)	664.6 ± 456.5 (29 - 1544)
Blood transfusion (%)	50 (30.5%)
3-day postoperative pain	2.4 ± 1.0 (1 - 5)
Postoperative time (days)	7.0 ± 1.5 (4 - 10)
Length of hospital stay (days)	11.7 ± 2.5 (8 - 17)

 Table 2: General information

Table	3:	Radiology
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	n = 164
Inclination (°) - Inside of range 30° - 50°	48.1± 5.4 118 (72%)
- Outside of range 30° - 50°	46 (28%)
Anteversion	$20.1 \pm 5.6$
- Inside of range 5° - 25°	139 (84.8%)
- Outside of range 5° - 25°	25 (15.2%)
Lewinnek's safe zone	
- Inside	97 (59.1%)
- Outside	67 (40.9%)
Angle of stem	
- Neutral	123 (75.0%)
- Valgus	34 (20.7%)
- Varus	7 (4.3%)
LLD	
- < 5 mm	115 (70.2%)
- 5 - 10 mm	44 (26.8%)
- > 10 mm	5 (3.0%)

Regarding the size of prosthesis, mean sizes of cup and femoral stem were 49.1 mm  $\pm$  2.4 and 11.6 mm  $\pm$  1.1 respectively. Especially, 90.2% of patients used heads with short neck (-2 mm or -3.5 mm)

The radiological assessment was presented (Table 3).

There were four intraoperative fractures and three postoperative periprosthetic fractures (Table 4).

Table	4:	Comp	lications

Kind of complicationsn = 7 (4.2%)		Need for reoperation n = 2 (1.2%)	Way the complication was handled	
Calcar fracture	4 (2.4%)	0 (0.0%)	Cerclage	
Periprosthetic fracture	3 (1.8%)	2 (1.2%)	Long cast, plate osteosynthesis, cerclage	

During the surgery, four calcar fractures occurred while inserting the stem and were reinforced with cerclages around the trochanteric region. These patients had weight-bearing lately after 3 weeks. Three cases had periprosthetic fractures that occurred after several months (2 or 7 months) or 3 years after surgery due to a fall. Two of the three cases needed revision by plate osteosynthesis and cerclages keeping the stem in place and one case could be handled conservatively by cast. There were no dislocation, no thrombosis, no infection and no aseptic loosening in our study.





**Figure 4:** (a) Calcar fracture treated by a cerclage, (b) (c) periprosthetic fractures (d) (e) periprosthetic fractures treated by plate osteosynthesis and cerclages.

At the last follow-up, the mean MHHS was  $92.1 \pm 7$ .

A	Мо	Tatal			
Age group	Fair	Good	Excellent	lotai	
60 - 69	2	8	38	48	
70 - 79	4	15	31	50	
≥ 80	8	15	11	34	
Total	14	38	80	132	
p = 0.0005					

Table 5. Comparison	MHSS	between	age	groups.
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The younger age group has significantly better hip function than the older (Table 5, with p = 0,0005).

### 4. DISCUSSION

There are several previous studies in the literature regarding the advantage of the DMC for THA, but there were just few studies describing the outcome exclusively for femoral neck fractures in the elderly treated by this procedure and this implant in Vietnam.

In our study, the main mechanism of injuries was falling, which 4 cases (2.4%) had upper limb fractures. In a study of almost 2,000 hip fracture patients, Robinson et al [13] reported an associated fracture or dislocation in just over 4% of cases. They are associated most commonly with upper limb fractures, mainly distal radial fractures and proximal humeral fractures. Patients with concomitant distal radial fractures were fitter than those with concomitant proximal humerus fractures and the latter group had a higher mortality rate [14]. In addition, more than 90% of our patients had a low bone loss mass (osteopenia and osteoporosis), which puts them at risk for fractures. Cummings et al. in a large study of bone density scans found that each standard deviation in femoral neck bone density increased fracture risk by 2.6 times after adjustment for age during an average follow-up of 1.8 years [15]. Therefore, after THA, doctors need to treat the osteopenia and osteoporosis for prophylaxis of second fractures.

In terms of accompanying diseases and ASA grade, most of the elderly had several comorbidities which was similar to another study [16 - 18]. Especially, 8 patients (4.8%) had Schizophrenia and Parkinson's syndrome. Currently, DMC is a well-accepted treatment option for any patient at an elevated risk for instability including patients with neuromuscular diseases, cognitive dysfunction, ASA score of 3 or more [11, 19].

There were outcomes of other studies using posterolateral approach (Table 5).

Authors	Age (years)	Patients	Operation time (minutes)	Length of incision (cm)	3-day post- operative pain	EBLV (ml)	Hospital stay (days)
Ait Mokhtar [20]	78	150	75	7	2.15	210	
Jaquot [21]	79	102	100	7		385	6.8
Macaulay [22]	82	17	89.1				7.7
Wani [23]	65	50	100				11.9
Our		164	66	7.4	2.4	363	11.7

Table 6: Comparison

Mean operation time was lower while figures for length of incision, EBLV and 3-day postoperative pain were quite similar to other studies (Table 6). Hospital stay is handled differently from country to country. Also, some of our patients had multiple accompanying diseases and required longer hospital stays for treatment.

A low dislocation rate was similar to authors using DMCs and lower than other studies using the same approach without DMCs (Table 7). In our study, most patients returned to usual daily activities with no limits of hip motion after 6 months. The same results could be observed in other studies [24, 25].

	Age (years)	Patients	Approach	Implant	Follow-up (months)	Dislocation (%)	HHS
Ait Mokhtar [20]	78	150	Postero - posterolateral	DMC	38	0.6	
Dorr [26]	69	39	Posterior	Not DMC	48	17.9	
Jaquot [21]	79	102	Postero - posterolateral	DMC	1.5	0	
Macaulay [22]	82	17	Posterola/ Anterolateral	Not DMC	24	5.8	84.2
Our		164	Posterolateral	DMC	6 - 64	0	92.1

 Table 7: Comparison

The dislocation rate depends on many factors such as approach, surgeon experience, miniinvasive approach or not, etc. Following literatures and many studies, THA using posterior approach had a higher dislocation rate compared to anterior approach [14]. Despite our study used posterolateral approach and 40.9% of cup's positions were outside of Lewinnek safe zone, our dislocation rate remained 0% due to several reasons. The effectiveness of DMC was proved to reduce this proportion by many studies [9, 10]. Ait Mokhtar et al. [20] showed the dislocation rate was 0.6% in a 150 patients with 38 months follow-up. In addition, several findings reinforced the theory put forward by other authors that Lewinnek's safe zone is not specific enough to differentiate between stable and unstable THA implantations [27, 28]. Furthermore, a careful capsular repair and reattachment of the short external rotators were performed as part of our closure to minimize the risk of this complication.

Regarding size of prothesis, Vietnamese acetabulums were quite small with 82.9% under 52, while the large size of femoral stem could related to osteoporosis in the elderly. Surgeons mostly used heads with short neck due to the fact that angle 135° of femoral stem and neck made a longer DLL intraoperatively.

The immediate post-operative radiological analysis found no more than 4° femoral stem varus, which is quite similar to Grégoire Thürig et al. [29]. Most cases (97%) had the DLL lower than 1cm, compared to 100% in study of Ei Bitar et al. [30] and 85.9% in study of Ishii et al. [31].

Our intraoperative complications using the posterolateral approach were slightly lower than described in other study [29]. It was classified as A2 following Vancouver, meanwhile these patients had normal rehabilitation with the exception of not weight-bearing the first three-week postoperation.

The main cause for postoperative periprosthetic fractures is falling. Poor bone quality due to osteoporosis is as well a known risk factor [32]. Our incidence (1.8%) was lower than other studies with 4.1 % [33] or 6.9% [29]. Marsland [34] described that 70 % had, prior to a periprosthetic fracture, signs of stem loosening. For those who suffered femoral neck fracture, the risk of suffering a periprosthetic fracture is higher as well [32], [35, 36]. Recent evidence from large registries has shown that the key to prevent periprosthetic femur fractures is routine follow-up with radiographic studies [32].

Regarding several criteria of MHHS, the oldest group had lower scores due to the lack of selfconfidence in walking without support or the fear of falling again while the younger ones could return to daily activities more easily.

### V. CONCLUSION

In term of instability after primary THA, DMCs is more alternative in preventing dislocation and having good outcomes in elderly patients with FNF. Longer follow-up duration may have revealed complications of DMC. Reported outcomes of studies using DM cups with mid-to long-term follow up should be encouraged to support their effectiveness.

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