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Dual Mobility Articulation in Conversion of Failed Proximal Femoral Fixation into Total Hip Arthroplasty

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ABSTRACT

Background: Failure of fixation of proximal femoral fractures (PFFs) that is mostly successfully treated with reduction and internal fixation may occur in cases with unstable fracture patterns, poor bone quality, or severe osteoporosis. Salvage options comprise either a revision of internal fixation or conversion arthroplasty.

Objective: This study describes the clinical and radiological outcomes achieved with dual mobility (DM) cups in the conversion of failed proximal femoral fracture fixation (PFFF) to total hip arthroplasty (THA).

Patients and Methods: From January 2020 to January 2024, a prospective study was conducted including 30 patients after failure of PFFF managed by conversion hip arthroplasty with DM cups. Posterior approach and DM cups were selected for all patients, either cemented or cementless, depending on bone quality. Indications for conversion procedure were PFF with mechanical failure, avascular necrosis, fracture nonunion, and secondary hip osteoarthritis. Radiological evaluation was performed to assess the position of acetabular and femoral components, cement mantle, and loosening, and functional assessment using the Harris Hip Score.

Results: This case series included 16 males and 14 females (12 right, 18 left). The mean age at the revision time was 63.2 ± 6.2 years. According to the original fracture, there were 9 patients with femoral neck fracture (FNF) (30%), 20 patients with intertrochanteric fracture (66.7%), and only one case with trochanteric fracture with subtrochanteric extension (3.3%). The indication for conversion THR was nonunion of the old fracture for 24 hips (80%), avascular necrosis for 5 hips (16.7%), and osteoarthritis secondary for fixation for only one hip (3.3%). Seventeen patients received cemented DM cups (56.7%), while 13 patients received cementless DM cups (43.3%). Standard cemented stem was used in 10 cases (33.3%), standard cementless stem in 13 cases (43.3%), and long stem (6 cemented and one cementless) in 7 cases (23.3%).

Conclusion: Patients with failed PFFF who used dual mobility cups experienced a lower incidence of dislocation and an improvement in their Harris Hip Score.

Keywords: THA; Dual mobility, Failed fixation; Proximal femoral fracture.

INTRODUCTION

The reported overall failure rates of failed proximal femoral fractures (PFFs) after internal fixation range from three percent to 12%, with device penetration occurrence (two percent to 12%), non-union in 2% to 5%, and malunion with varus deformity in 5% to 11% [(1)].

Failure of PFF is usually attributed to osteoporotic fractures, unsatisfactory fracture reduction, infection, and early postoperative weight-bearing (WB) before fracture consolidation. With reported incidence both proximal femoral nail (PFN) and dynamic hip screw (DHS) [(2,3)].

In case of nonunion of PFFs in young adults who received internal fixation, revision of internal fixation has been reported to have satisfactory results due to good bone stock, while in elderly hip arthroplasty is preferable a salvage procedure due to poor bone quality and arthritic changes [(4)].

Surgical intervention following a failed trochanteric or subtrochanteric fracture is usually challenging due to associated comorbidities, altered anatomy from the primary fracture and its fixation, bone loss, presence of holes after of internal fixation device removal, nonunion, malunion, and poor bone quality [(5-7)].

Hemiarthroplasty for low functional demands elderly patients with intact acetabulum is an option, while for those patients with higher functional level of activity and more life expectancy THA is a more optimal alternative. In the context of screw cutout and acetabular cartilage erosion, a THA should be conducted, irrespective to the patient functional demands, to restore acceptable hip function [(8)].

During the conversion to THR, intraoperative complications may occur such as periprosthetic fractures or cracking and blood loss. Postoperative complications may occur such as superficial or deep infection or instability, the last remains the most significant complications. The reported incidence of instability following primary and revision THR is high (seven percent and 25%, correspondingly). With a cumulative risk of first-time dislocation of 2% in one year and seven percent at 15 years of primary THR [(9,10)]. The DM articulation concept was introduced in 1970 by Bousquet to increase the range of motion (large head) and to reduce the incidence of dislocation as a main advantage, with less incidence of impingement, lower friction, and lower wear (small head) [(11)].

We aimed to describe the clinical and radiological outcome achieved with DM articulation in the conversion of failed proximal femoral fracture fixation (PFFF) to THA.

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PATIENTS AND METHODS

Study design:

This study was a single-center prospective case series including 30 patients receiving DM THA in failed PFFF between 2020 and 2024, with a follow-up period ranging from 12 to 47 months. Prospective collection of data was conducted in a local database to confirm high-quality recording.

Patients' selection:

Patients who received dual mobility THR for management of failed PFFF (Nonunion, avascular necrosis (AVN) or 2ry OA of hip joint) throughout the study period irrespective of patient age, primary fracture pattern, BMI, or patient level of activity. Infected cases, pathological fractures, and cases who died or lost follow-up were excluded.

Surgical technique:

Through the hip posterior approach, good exposure was done. The failed implant became prominent, and we started to remove it. After implant removal and hip dislocation, the soft tissue osteophytes around the acetabulum were excised to visualise the acetabular edge and true floor circumferentially. Reaming and preparation of the acetabular side was done using transverse acetabular ligament (TAL) as a landmark for cup positioning. Reaming of the acetabulum stopped when reaching bleeding subchondral bone proper reamer stability. A line-to-line trial component to ensure the primary stability, cup size, and orientation of component was used. The Coptos TH cup (NOVAE® product line SERF, Décines-Charpieu, France) was implanted with extra-articular fixation by utilizing screws across the superior flanges and hydroxyapatite (HA) coated pegs into the ischium and pubis in the case of cementless implants when a stable rim contact was possible.

On the femoral side, femoral side preparation differs in failed fixation of intracapsular fracture from extracapsular; **intracapsular:** started with the use of box osteotome to remove box of cancellous bone at the site of entry of the medulla. Gradual broaching was done to open the medullary canal, **extracapsular:** femoral preparation in these cases was done through the fracture site then we started to open the medulla by gradual broaching until reaching a size that is rotationally stable with subsidence on further hammering, with taking care of reaching good stability and reaching equal length with the other side that do not interfere with joint stability. Reattachment of the greater trochanter in all cases was done using soft wires but we delayed tensioning of the soft wires after actual stem insertion was done.

The largest broach that attained both rotational and vertical stability determined the stem's size. Using manual pressure and hammer impaction, a cementless stem of the same size as the previous broach was introduced until it was firmly seated. In Dorr types A and B, medullary canals with adequate bone quality cementless stems were inserted. While in Dorr Type C medullary canals with poor bone quality, cemented stems were inserted.

The broaches' successive sizes were used to prepare the canal. The goal was to remove loose cancellous bone, while preserving the robust cancellous trabecular bone. The plug was then inserted five millimeters distal to the stem tip, the medullary canal was irrigated with saline, and it was dried with sterile gauze and a suction-connected catheter.

The medullary canal was retrogradely filled with standard-setting bone cement laced with antibiotics using a syringe gun. Then, by utilizing the medullary top seal and hand pressure, cement was pressurized inside the medullary canal. Finally, stem insertion was carried out using hand-sustained pressure to the appropriate level. Finally, after reduction and application of the final implant, testing stability was done by flexion and abduction with internal rotation.

Patient evaluation and follow-up:

Data collected and analysed included implant details, loosening of cementless or cemented implants, postoperative problems or revisions, radiolucent lines in any Gruen zone, stem subsidence, infections, and radiological indications of bone ingrowth around cementless stems.

Functional evaluation was performed during follow-up visits at two, four, six weeks, three months, six months, one year, and then annually. Radiological assessment was conducted by utilizing the operative hips' lateral and anteroposterior radiographs. Clinical evaluation was conducted by utilizing the modified Harris Hip Score for each patient with a minimum one-year follow-up (mHHS) [(12)].

Ethical approval:

Approval from the institutional review board of Faculty of Medicine, Menoufia University was obtained, and written informed consent was taken from patients. The study adhered to the Helsinki Declaration throughout its execution.

Statistical analysis

IBM SPSS version 20.0 was used to analyze the data that was fed into the computer. Numbers and percentages were utilized to define the qualitative data. Range, mean, and standard deviation were used to characterize quantitative data.

RESULTS

Under the supervision of arthroplasty surgeons, all procedures were carried out at a university hospital that offers free medical care. Senior consultants, consultants, and supervised trainees carried out the surgical procedures. The surgical procedure was performed on six patients by supervised trainees, thirteen by consultants, and twenty-one by senior consultants.

Patients' characteristics and information:

This case series included 16 males and 14 females (12 right, 18 left). The mean age at the time of revision was 63.2 ± 6.2 years (range, 55 to 79).

In our study, according to the original fracture, we had nine patients with femoral neck fracture (30%), twenty patients with intertrochanteric fracture (66.7%), and only one case with trochanteric fracture with subtrochanteric extension (3.3%).

The indication for conversion to THR was nonunion of the old fracture for 24 hips (80%), avascular necrosis for 5 hips (16.7%), and osteoarthritis secondary for fixation for only one hip (3.3%). Seventeen patients received cemented DM cups (56.7%), while thirteen patients received cementless DM cups (43.3%). The only cups and construct combinations that were not included in this research were DM articulations, and only one design (NOVAE® Coptos TH–SERF, NOVAE® Stick – SERF) was employed. In this study, the standard cemented stem was used in 10 cases (33.3%), the standard cementless stem in 13 cases (43.3%), and the long stem (6 cemented and one cementless) in 7 cases (23.3%), (Table 1 and Figs 1,2).

Beginning on the first postoperative day, all cases were permitted to touch WB, which increased from partial to full WB in three months.

The mean preoperative Harris hip score was 26.47 ± 11.75, with a range of 6 to 47. In the most recent follow-up, the postoperative Harris hip score had a mean of 85.41 ± 9.32 and ranged from 60 to 98.

Table (1): Epidemiologic data, clinical outcome, distribution of the studied cases based on implant removed, and indications for revision surgery

		Conversion total hip arthroplasty by DM cups (no=30)
Age (years)		55 to 79 years old with a mean age of (63.2 ± 6.2 years)
Gender	Female	14
	Male	16
Side	Right	12
	Left	18
Interval period (years)		2.88 ± 4.97
Preoperative HHS		26.47 ± 11.75
Postoperative HHS After 1 year (n = 29#) one case died		85.41 ± 9.32
Distribution of the studied cases based on implant removed (n = 30)		PFN 3 cases D.H.S 11 cases D.C.S 1 case Gamma nail 3 cases Trochanteric plate 4 cases Cannulated screws 7 cases D.H.S and plate 1 case
Indications for revisions		Revision for secondary OA hip (1 case)
		Revision for AVN hip (5 cases)
		Revision for nonunion (24 cases)

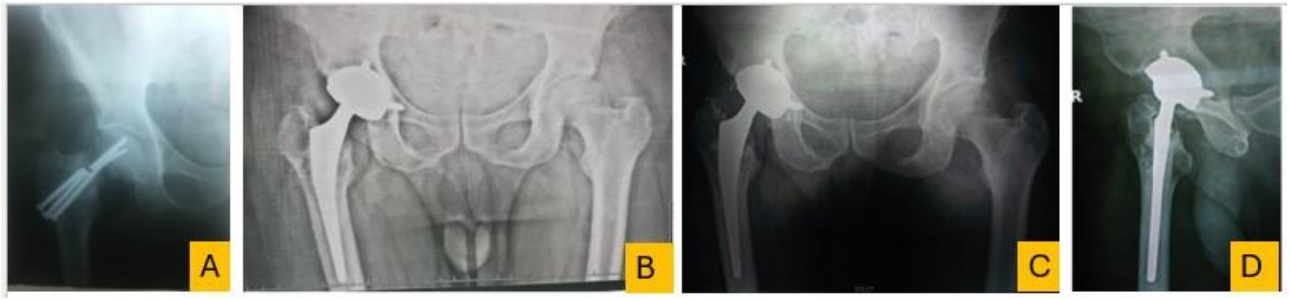

Fig. (1): 57 years old male patients who had failed fixation of FNF fixed by cannulated screws; (A) preoperative X-ray with broken cannulated screws, (B) six months postoperative X-ray, (C, D) one-year postoperative follow up.

Fig. (2): 78 years female patient who had failed fixation of trochanteric fracture fixed by trochanteric plate; (A, B) preoperative X-ray showing nonunion and deformity, (C) postoperative X-ray, (D, E) one-year postoperative X-ray.

Radiographic assessment:

At follow-up visits, radiological evaluation was conducted using anteroposterior hip radiographs to evaluate the femoral offset, acetabular inclination regarding the inter-teardrop line (preferably 45º), femoral stem orientation (preferably neutral or slight valgus 5º), component migration, change in component alignment, presence of heterotopic ossification, osteolysis, and, if reattachment was performed, loosening and union of the reattached trochanter.

A comparison was conducted between the X-rays obtained during the most recent follow-up and those taken after surgery. At the points where the cup and host bone met, all cups exhibited good osteointegration and stability. The cup abduction angle did not change. There were no radiolucent lines visible surrounding the cups.

Patient readmission:

For closed reduction of hip dislocation under general anesthesia, only one patient was readmitted to the operating room.

Complications:

There was only one case that suffered from intraoperative arrest and was admitted to the ICU postoperatively. According to postoperative complication, twenty-seven patients had no complications (90%), and three patients had complications (10%) one case with partial and transient sciatic nerve affection, the function recovered fully after seven months. Second case had intraprosthetic dislocation in the ICU after 4 days during care, dislocation was reduced under sedation. The third case died after two days in the ICU due to pulmonary embolism.

Table (2): Distribution of the studied cases according to postoperative complications (n = 30)

Postoperative complications	No.	%
No	27	90.0
Yes	**3**	**10.0**
Sciatic nerve injury	1	3.3
I.CU. Death	1	3.3
I.C.U. Dislocation	1	3.3

DISCUSSION

This prospective case series evaluated the outcomes of dual mobility cups in total hip replacement (THR) after failed internal fixation of proximal femoral fractures (PFFs). The primary objective was to determine the rate of dislocation and reliability of dual mobility cups in this challenging patient population.

Our study included 30 patients with a mean age of 63.2 years (range from 55 to 79 years) at the time of revision, who underwent conversion hip arthroplasty by utilizing DM cups after failed osteosynthesis for PFFs. The results showed significant improvement in functional scores (Harris Hip Score) over a one-year follow-up period, with no reported cases of dislocation. Two cases of superficial infection were observed, but no major complications were noted.

Infected cases, pathological fractures, and cases treated primarily with arthroplasty were excluded

from this study. The sites of primary fracture were femoral neck in 9 cases (30%), intertrochanteric in 20 cases (66.7%), and combined trochanteric with subtrochanteric in one case (3.3%). The most common technique used for proximal femur fracture stabilization was dynamic hip screw, followed by cannulated cancellous screw and proximal femoral nail according to the type of fractures.

The use of DM cups in THR following failed fixation of PFFs has been recorded in preceding studies. **Morice *et al.*** [13] recorded the usage of DM cups in thirty-five cases of failed fixation of PFFs with fourteen cases with extracapsular fractures and twenty-one with intracapsular fractures. The study reported favorable functional outcome scores with a mean Harris hip score of 74. Four cases of dislocation were reported in this study but were related to the ordinary cups with no cases of dislocation in the dual mobility ones. No doubt that secondary hip arthroplasty after failed fixation differs from operations done in virgin hips. Higher rates of complications (such as increased blood loss and intraoperative fractures) are linked to the surgery. **Pui *et al.*** [14] reported a greater incidence of adverse events in the THA group following nail fixation, regardless of the type of internal fixation technique employed during fracture fixation.

The challenges associated with THR after failed fixation of PFFs include muscle weakness, compromised abductor function, bony defects, and difficult implant positioning, which increase the risk of instability. Dual mobility cups address these challenges by providing a larger femoral head and improved stability. Only one periprosthetic fracture and one dislocation were discovered by **Hammad *et al.*** [15] in their assessment of 32 patients undergoing THA following a failed DHS fixation. At the most recent follow-up, 78% of patients had satisfactory or excellent clinical results. **Zhang *et al.*** [6] examined 19 of these patients and discovered that intraoperative fractures of the greater trochanter and postsurgical dislocations were frequent. There were no revisions related to mechanical failure.

Archibeck *et al.* [5] reported that in 102 cases of failed fixation treated with total hip arthroplasty, the mean Harris hip score was 84 and 4.9% was the rate of dislocation using cementless acetabular components but they did not mention the use of DM cups in their series.

According to **D'Arrigo *et al.*** [16] modular implants with long stems were used in 14 out of 21 cases who had THA for intertrochanteric fractures that did not respond to treatment. The study found no proof of a markedly increased risk of complications in these subjects, and their clinical results were satisfactory. Non-cannulated, threaded pins were frequently used in the early stages of this study to treat femoral neck fractures managed with internal fixation. Cannulated 7.0-mm screws were later found to be responsible for the majority of these patents.

Entire THAs conducted after failed internal fixation of PFFs were conducted with the use of dual mobility cups. The dual-mobility idea merged Charnley's "low-friction arthroplasty" philosophy with McKee's advantage of a big femoral head. Challenges including muscle weakness, affection of abductor functions, bony defects and difficult implant positioning are the risk factors of instability after failed fixation of PFFs. The mean Harris hip score before surgery was 48.3, and it increased to 85.1 at the final follow-up in another study by **Philippot *et al.*** [17] that examined 137 hips in 114 patients who had complete hip replacements utilizing dual mobility cup.

Thirteen cementless cups and seventeen cement cups were used in this investigation. At the final follow-up, no loosening in the femoral stem was found, and none of the cups displayed any migration, osteolysis, loosening, or heterotopic ossification. This study included 30 patients who had dual mobility THA, no large articulation dislocation, and a minimum follow-up time of one year. Since intraprosthetic dislocation is regarded as a midterm and long-term problem associated with the wear process of the movable polyethylene insert, no intraprosthetic dislocation was found throughout the study's brief follow-up period. The major articulation dislocation rate was 0% at the mean follow-up of six years in research by **Hamadouche *et al.*** [18] that involved 168 patients who had primary THA using cementless DM cups; nevertheless, there were 4 instances of intraprosthetic dislocation. In another study conducted by **Vermersch *et al.*** [19]**,** on a total of 100 cases underwent THA using cementless DM cup with a mean follow-up of 6 years, there were no large articulation dislocation nor intraprosthetic dislocation reported.

The success rate in this study was 90% with a 10% complication rate due to postoperative sciatic nerve injury in one case, postoperative death in one case and postoperative dislocation in ICU unit in a single case. Compared to recent studies published in the literature, this study demonstrated good clinical and radiological outcomes with no dislocation or intraprosthetic dislocation, supporting the use of DM cups in preventing the risk of dislocation in patients after failed PFFF, where the patients are at considerable risk of dislocation. The outcomes support the use of DM cups as a reliable solution for this challenging patient population.

The small sample size and lack of randomization may be the study's weaknesses. Also, other limitations include being a non-blinded non-controlled prospective study, with a short follow-up period to assess long-term complications and implant survival. Future research should focus on multicenter studies, case-controlled studies with medium to long-term follow-up, and reporting patient-reported outcome measures (PROMs) after THR.

CONCLUSION

Patients with failed PFFF who used DM cups experienced a lower incidence of dislocation and an improvement in their Harris Hip Score.

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