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Original Article

Cemented unipolar or modular bipolar hemiarthroplasty for femoral neck fractures in elderly patients - which is better?

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Abstract: Introduction: Hemiarthroplasty is considered to be the treatment of choice for femoral neck fractures in elderly, however there is no consensus to support the choice between unipolar or bipolar hemiarthroplasty. Several studies found that patients with bipolar hemiarthroplasty had a better outcome of pain, a higher rate of return to the pre-injury state, and a greater range of hip motion. Some studies have demonstrated equal hip functional outcome between unipolar and bipolar hemiarthroplasty, but unipolar hemiarthroplasty was favoured due to its lower cost. The purpose of this study was to compare the functional and radiological outcome of cemented unipolar vs modular bipolar hemiarthroplasty in displaced femoral neck fracture in elderly patient population. Methods: It is a prospective randomized study, with 44 patients in each group. Elderly Patients (>60 years of age) with traumatic displaced femoral neck fractures were included in the study. Cemented unipolar or modular bipolar hemiarthroplasty was performed in the respective patient groups using posterior or anterolateral approach. Functional outcome evaluation was done by Harris Hip Score and radiological outcome evaluation was done for acetabular erosion. The data was entered in MS EXCEL spread sheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 20.0 (IBM, Chicago). Results: The mean age in the unipolar and bipolar group was 67.2 and 66.1 years respectively. The average follow-up period was 20.1 and 22.3 months in the unipolar and bipolar group respectively. Mean operating time was significantly more in the modular bipolar group (78.3 minutes) compared to the unipolar group (67.3 minutes). Two patients (4.5%) had acetabular erosion in each group. Mean Harris Hip score at 3 months follow-up was significantly higher (p value <0.05) in bipolar group (75.8±4.2) than the unipolar group (77.7±2.9). However, subsequent follow-ups at 6 months (80.9±2.8, 82.0±2.5, p value >0.05) 12 months (83.1±2.2, 83.2±1.2, p value >0.05) and 24 months (85.5±2.4, 85.2±2.8, p value >0.05) did not show any significant difference between the two groups. The incidence of general complications was 34% in bipolar and 20.4% in unipolar hemiarthroplasty group. Conclusion: Functional outcome in terms of Harris Hip Score are better in the bipolar group at 3 months follow up but there was no significant difference in the functional outcome between the two groups at 6, 12 and 24 months follow up. The operative time for unipolar is lower and statistically significant compared to bipolar hemiarthroplasty of the hip.

Keywords: Hip, fracture, neck femur, surgery, hemiarthroplasty, bone cement

Introduction

Femoral neck fractures are extremely common in the elderly. Intracapsular femoral neck fractures account for over 50% of all hip fractures [1]. The lifetime risk of sustaining a hip fracture is high and lies within the range of 40% to 50% in women and 13% to 22% in men [2]. Major fracture specific risk associated with this injury is non-union and avascular necrosis of femoral head. Besides, femoral neck fractures in the elderly may lead to significant morbidity, mortality, loss of function, and independence among the survivors [3]. Due to poor clinical results, femoral neck fracture is referred to as an “unsolved fracture” [4]. The primary goal of treatment is to restore the pre-fracture functional status of the patient [5].

Various treatment options include reduction and fixation, unipolar or bipolar hemiarthroplasty, and total hip arthroplasty (THA) [6, 7]. Among these procedures, hemiarthroplasty has become the most preferred treatment

option for surgeons according to the surveys [7-9]. Internal fixation is associated with high levels of complications (osteonecrosis, nonunion) and is therefore, not commonly favoured as a method of treatment for elderly people [10]. While hemiarthroplasty addresses most of these fractures; there is not enough evidence to support either of the two treatment modalities. Important considerations in selecting any treatment modality are intrinsic, i.e. patient age, general medical condition, type of fracture; and extrinsic, i.e. availability of facilities and socioeconomic status.

A hemiarthroplasty of hip can be either unipolar or bipolar. A unipolar hip prosthesis has a one-piece design where the hip movement occurs between the prosthesis head and the native acetabulum. Unipolar prostheses are broadly of two types, Austin Moore and Thompson prosthesis. Austin Moore prosthesis has fenestrations in the stem through which bone ingrowth can occur aiding to anchorage of hip prosthesis to the native bone; these fenestrations are however absent in Thompson prosthesis and it relies on bone cement for fixation to the native bone. A bipolar hip prosthesis has an additional joint between the outer shell and the head of the prosthesis. This special design provides an additional motion between prosthesis head and its outer shell. Second motion takes place between outer shell and the native acetabulum. Bipolar hip prosthesis can be modular or nonmodular. A modular bipolar hip prosthesis offers the advantage of making adjustment for limb length discrepancy during surgery.

Few studies have found that patients with bipolar hemiarthroplasty had a better outcome of pain, better quality of life, a greater range of hip motion, and a faster walking speed [11-13]. However, the advantages of bipolar hemiarthroplasty are not proven in other studies demonstrating equal hip functional outcomes between unipolar and bipolar hemiarthroplasty, but unipolar hemiarthroplasty was favoured due to its lower cost. Predicted benefits of bipolar prosthesis include less acetabular wear, possibly less groin pain and ease of conversion of modular bipolar to a total hip replacement (THR) [14-17]. The theoretical advantage of a bipolar prosthesis is due to movement within the implant rather than between the prosthesis head and the acetabulum, which results in less acetabular erosion. However, some studies suggested that shortly after implantation the motion at the inner bearing ceases, converting the prosthesis to a unipolar implant [18]. Also, polyethylene can cause particulate debris leading to osteolysis [19]. The higher cost of modular bipolar prosthesis precludes its use in patients belonging to lower socioeconomic status. This study aimed to compare the treatment outcome of cemented unipolar and modular bipolar prosthesis in elderly patients with femoral neck fracture.

Methods

Study design

This was a randomized prospective study done between Nov. 2017 to Dec. 2020 at a tertiary health care centre. The study was conducted after approval from institutional ethical committee (D.No-1014/FM). An informed written consent was obtained from all study participants.

Inclusion and exclusion criteria

Patients >60 years of age with traumatic displaced femoral neck fractures were included whereas; patients who had an undisplaced/impacted or pathological femoral neck fracture were excluded.

Patient randomization and group allocation

Total of 120 patients were included in the study. Sixty patients each were randomised to both unipolar and bipolar group respectively. At last follow-up 44 patients were available. Patients who satisfied inclusion criteria were randomized into group A (cemented unipolar prosthesis) and B (cemented modular bipolar prosthesis). All odd number patients were allotted to group A and Even number patients were allotted to group B. All study participants underwent a thorough clinical and radiological examination as per the predetermined protocol.

Surgical intervention and implant used

Hemiarthroplasty was performed in all patients through posterior or anterolateral approach depending upon surgeons' preference. In unipolar group after exposure of the hip joint

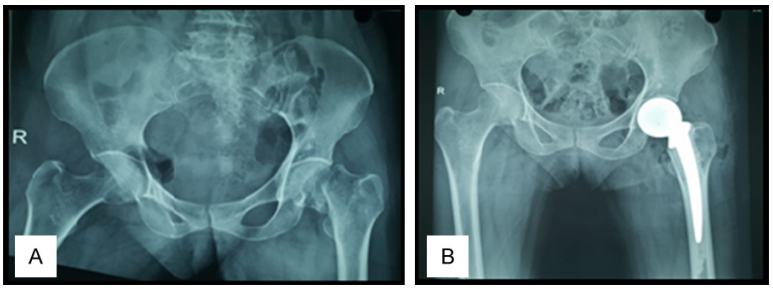

Figure 1. Pre-operative (A) and post-operative (B) anteroposterior (AP) radiograph of pelvis including both hips of a 65 year old female who sustained femoral neck following fall from stairs and treated with cemented unipolar (Thompson) prosthesis.

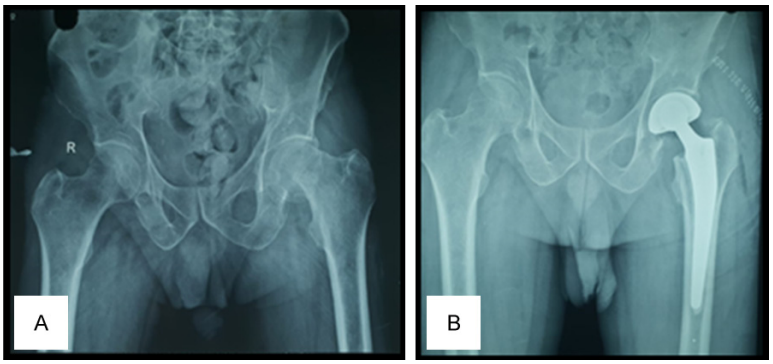

Figure 2. Pre-operative (A) and post-operative (B) AP radiographs of pelvis including both hips of a 60 year old male, who suffered a fall in bathroom and sustained fracture neck of femur and was treated with cemented modular bipolar prosthesis.

using either posterior or anterolateral surgical approach, the femoral head was delivered out. This was followed by the preparation of the femoral canal using sequential broaches into the femoral canal. The bone cement is prepared and filled into the femoral canal, followed by insertion of the prosthesis and subsequent reduction of the hip joint. The stability of the hip joint was checked, once found satisfactory wound was closed (**Figure 1**). In bipolar group patients after exposure of the hip joint using either of the two surgical approaches the hip joint was exposed. This is followed by an appropriate femoral neck cut and preparation of the femoral canal using sequential femoral canal rasps. Then, trial prosthesis was used to determine the appropriate femoral neck length and stem size for the individual patient. After final trial the cement restrictor was inserted into the femoral canal and an appropriate sized femoral prosthesis was inserted followed by reduction of the hip joint and wound closure was done (**Figure 2**). A single shot of injection cefoperazone and sulbactum was given to all patients one hour prior to surgical incision.

Postoperative protocol

All patients were given injectable analgesics in the immediate postoperative period. Second day after surgery patients were switched to oral analgesics. Static quadriceps drill and ankle Range of Motion exercise were started in evening of the operation day. Next day patients were encouraged to sit and do hip and knee ROM exercises depending upon patients' tolerance to pain. First wound inspection was done on 3rd postoperative day, if found satisfactory injectable antibiotics were stopped. Stitch removal was done at 2 weeks and patients were followed at 3 months interval for the first year and at 6 months interval thereafter.

Outcome evaluation

Functional outcome evaluation was done using Harris Hip score (HHS). This score system includes assessment of pain, function, deformity and hip range of motion. The maximum possible score in a given patient is 100 [25]. Radiological outcome evaluation was done for acetabular erosion using anteroposterior radiograph of the operated hip joint using criteria described by Baker. According to this system Grade 0 refers to normal, Grade 1 is narrowing of articular cartilage without erosion, Grade 2 refers to acetabular bone erosion with early migration and Grade 3 refers to protrusio acetabuli [26].

Statistical analysis

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD. Quantitative variables were compared using an inde-

Table 1. Preoperative patient characteristics between groups A (unipolar) & B (bipolar) patients

Patient variable	Unipolar (group A)	Bipolar (group B)	*p* value
Age			>0.05[a]
Average (years)	67.2	66.1	
Range (years)	60-81	60-81	
Gender			>0.05[a]
Male	25	18	
Female	19	26	
Side			>0.05[a]
Left	27	29	
Right	17	15	
Ambulatory status			>0.05[a]
Community ambulators	28	24	
Household ambulators	16	20	
ASA grading			>0.05[a]
Grade 1 & 2	32	24	
Grade 3 & 4	12	20	
Singh index			>0.05[a]
Grade 1	17	8	
Grade 2	9	18	
Grade 3	10	12	
Grade 4	8	6	
Garden classification			>0.05[a]
Grade 2	2	2	
Grade 3	14	15	
Grade 4	28	27	

There was no statistically significant difference in the pre-operative characteristics between the groups. a = chi square test.

Table 2. Intraoperative assessment between unipolar and bipolar hemiarthroplasty patients

Variable	Unipolar	Bipolar	*p* value
Surgical approach			>0.05[a]
Anterolateral	6	13	
Posterior	38	31	
Operative time (min)	67.3	78.3	<0.05[a]
Blood loss (mL)	238.8	243.6	>0.05[a]

a = chi square test.

pendent t-test. Qualitative variables were assessed using the chi-square test. A *p*-value of <0.05 was considered statistically significant. The data was entered in MS EXCEL spread sheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 20.0 (IBM, Chicago).

Result

A total of 120 patients were enrolled in the study. Eight patients died in Group A and 10 patients died in Group B, while 8 patients were lost to follow up in Group A and 6 patients were lost to follow up in Group B, hence rendering 44 patients each in Group A and Group B. Preoperative data shows no significant difference in the distribution of age, sex, pre-injury ambulatory status, degree of osteoporosis, and comorbidities between the two groups [**Table 1**]. Mean operating time was significantly more in the modular bipolar group (78.3 minutes) compared to the unipolar group (67.3 minutes). However, there was no statistically significant difference in mean blood loss (238.8 mL in unipolar and 243.6 mL in bipolar) among the two groups [**Table 2**].

Two patients had acetabular erosion (grade 1=1, grade 2=1) in bipolar group at 18 months follow up (**Figures 3**, **4**) and two patients had acetabular erosion (grade 1=1, grade 2=1) in unipolar group at 12 months follow up. Three patients in our study had mild coronal plane malalignment in unipolar group [**Table 3**]. Follow-up at 3 months showed significantly higher Harris Hip score in bipolar group than the unipolar group. However at subsequent follow-ups at 6, 12, and 24 months did not show any significant difference between the two [**Table 4**].

One patient in the Group A developed a urinary tract infection (UTI) which was resolved by injectable antibiotics. Two patients in unipolar group and one in bipolar group developed superficial pressure sores. One patient in Group B developed pneumonia during the hospital stay but it settled down by injectable antibiotics. There were no major intraoperative complications except splinter of the neck which extended to shaft in one patient of Group A in which encirclage with stainless steel wire was done and another patient had hairline partial thickness splinter of the greater trochanter Group B. There was no case of sciatic nerve paresis or dislocation in our study. 11 cases had superficial wound infection; 6 in Group A and 5 in Group B. All patients with superficial

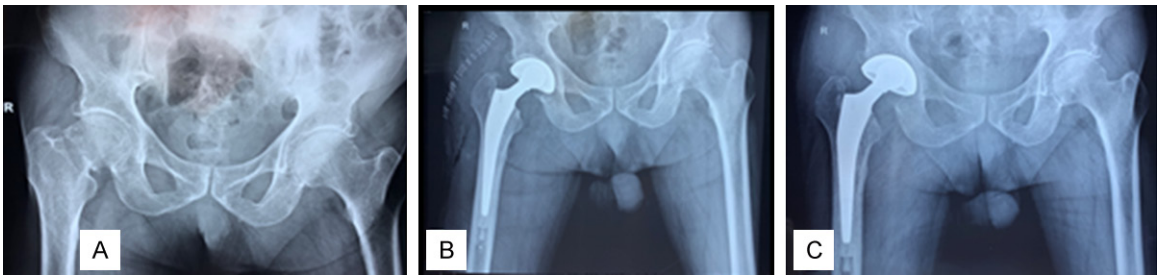

Figure 3. Pre-operative AP radiograph of pelvis including both hips of a 70 year old male who sustained femoral neck fracture (A); immediate post-operative AP radiograph of same patient treated with cemented modular bipolar prosthesis (B); 18 months post operatively shows grade 2 acetabular erosion (C).

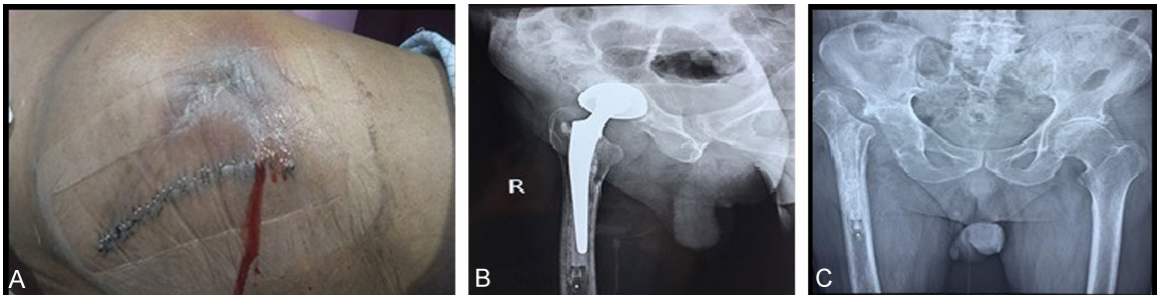

Figure 4. Clinical photograph of operated hip of a patient who developed deep wound infection with history of pus discharge (A); AP radiograph of pelvis including both hips showing infected bipolar prosthesis with grade 3 acetabular erosion just before removal (B) and Postoperative AP radiograph of the same patient after Prosthesis removal due to deep wound infection (C).

Table 3. Post-operative assessment including complications in group A & B patients

Parameters	Unipolar (group A)	Bipolar (group B)
Time to full weight bearing (mean value in days)	2.3	2.2
Duration of hospital stay (mean value in days)	15.1	15.5
Time between injury to surgery (mean value in days)	18.2	15.4
Complications		
UTI	1	0
Pneumonia	0	1
Pressure sore	2	1
Superficial wound infection	6	5
Deep wound infection	0	4
Reoperation	0	4
Heterotopic ossification	0	1
Total no. of general complications	9	12*
Radiological outcomes		
Aseptic loosening	0	0
Varus stem position	2	0
Valgus stem position	1	0
Neutral stem position	32	36
Acetabular erosion	2	2
Total no. of implant related complications	4**	1**

*excluding reoperation, **excluding neutral stem position.

wound Infection settled by conservative treatment. Four patients in Group B had deep wound infection. All of them were reoperated within 1 week of index surgery. One patient with deep infection, and had continuous dull aching hip pain and difficulty in walking with joint stiffness, underwent implant removal (**Figure 4**). After that wound healed uneventfully. The remaining three patients underwent wound debridement surgery and all of them healed with the closure of the wound at a later stage [**Table 3**].

Discussion

The goal of this study was to compare functional and radiological outcomes in patients receiving cemented unipolar or bipolar hemiarthroplasty and

Table 4. Functional outcome in terms of Harris Hip Score (HHS) in group A & B patients at 3, 6, 12 and 24 months follow up

Duration	Mean HHS of Unipolar group	Mean HHS of Bipolar group	*p*-value
3 months	75.8±4.2	77.7±2.9	<0.05[b*]
6 months	82.0±2.5	80.9±2.8	>0.05[b*]
12 months	83.2±1.2	83.1±2.2	>0.05[b*]
24 months	85.2±2.8	85.5±2.4	>0.05[b*]

b* = independent paired t test.

determine whether bipolar prosthesis would result in improved patient outcomes. By specifying the inclusion criteria precisely, we were able to define a more homogeneous group, perhaps more representative of most geriatric patients suffering from hip fractures.

Functional outcome

Somashekhar compared 21 cases of bipolar hemiarthroplasty and 20 cases of Austin Moore prosthetic replacement for femoral neck fractures in the elderly at one year follow-up and concluded that the bipolar hemiarthroplasty group had a significantly better outcome than the unipolar group over one year [21]. However, Hedbeck on comparing unipolar and bipolar prosthesis did not find any significant difference in HHS at 12 months [22]. Similarly Wathne in 1995 based on the results of their study, concluded that there's no advantage to the use of bipolar endoprosthesis for the treatment of femoral neck fractures in the elderly patient [23]. In our study mean HHS at 3 months was significantly better in bipolar group (77.7±2.9) when compared to unipolar group (75.8±4.2). At 6 months HHS in unipolar group was 82.0±2.5 and in the bipolar group it was 80.9±2.8 (*p*-value >0.05). At 12 months follow up mean HHS in unipolar and bipolar group was 83.2±1.2 and 83.1±2.2 respectively, however the difference was not statistically significant (*p* value >0.05). Final follow up at 24 months revealed mean HHS of unipolar group and bipolar group as 85.5±2.4 and 85.2±2.8 respectively, which was not statistically significant (*p* value >0.05). So in our study the functional outcome in terms of mean HHS was better in bipolar hemiarthroplasty group initially but at longer follow up we could not elicit any advantage of bipolar hemiarthroplasty over unipolar hemiarthroplasty for femoral neck fractures in elderly. This observation from our study is in agreement with the study of Hedbeck and Wathne as mentioned above and also supported by the fact that that a bipolar hip prosthesis works as a unipolar prosthesis after 3-12 months of hemiarthroplasty [18, 24].

Radiological outcome

Acetabular erosion is a common long term complication after hemiarthroplasty taking place months to year after surgery and can lead to severe pain, which impedes functional outcome and may ultimately lead to revision surgery [25]. The etiology is unclear but may include direct injury from initial trauma as well as wear of the native cartilage against a non-anatomic bearing surface. It has been correlated with increased activity and length of time from surgery [26]. Hedbeck found 20% vs 5% rate of acetabular erosion in unipolar compared to bipolar hemiarthroplasty [16-22]. Baker has also reported 66% rate of acetabular erosion following unipolar arthroplasty at a mean follow-up of 39 months [27]. In our study, we found two acetabular erosion (4.5%) each in unipolar and bipolar hemiarthroplasty groups. The lower incidence of acetabular erosion in our study may be attributed to relatively shorter period of follow-up and younger age (>60 years) of patients in our study compared to study of Hedbeck (>80 years) [21]. Yang in a systematic review and meta-analysis of unipolar vs bipolar hemiarthroplasty in displaced femoral neck fractures in elderly found acetabular erosion in 5.5% and 1.2% in unipolar and bipolar hemiarthroplasty patients respectively [30]. Three patients in our study had mild coronal plane malalignment (2 stem varus and 1 stem valgus in unipolar group). There was no stem malalignment in bipolar group; we attributed this to the use of stem centralizer in modular bipolar hemiarthroplasty. However coronal plane malalignment in unipolar did not significantly alter the functional outcome, because the literature shows that a mild coronal plane malalignment may not adversely affect the outcome of hip arthroplasty [28]. Similar stem malalignment has not been emphasized by other authors; this may be due to the fact that there was no stem malalignment in their studies.

General complication

The overall incidence of general complications was higher in bipolar group (34%) compared to

unipolar group (20.4%). Hedbeck has also reported an incidence of 12% and 22% general complications in unipolar vs bipolar group [21]. In our study two patients in unipolar hemiarthroplasty group (delayed surgery =1, delayed walking due to iatrogenic fracture =1) developed bed sore. One patient in bipolar hemiarthroplasty group had incomplete hairline fracture of greater trochanter and was advised delayed weight bearing, also developed bedsore. All three patients were between 75-80 years of age with fragile skin. Pressure sores in all three patients healed as the patient started walking along with supportive nursing care.

Cost analysis

Cost containment has become a topic of extreme importance, especially in resource limited area, where the majority of the patients belong to lower socioeconomic status. Because of the complexity of factors involved in calculating expenses met by the patient and his family during hospital stay (cost of prosthesis, cost of drugs, hospital charges, and miscellaneous) the exact cost could not be determined. However, hospital expenses were significantly more in the Bipolar group (Rs. 29707=406 USD) when compared to the Unipolar group (Rs. 5075=69.48 USD). Saving of Rs 24,632 (337.2 USD) could be achieved per patient by using the unipolar prosthesis. In the study done by Cornell the cost difference between the unipolar and bipolar group was significant ($700.00 per case) [13]. Few authors justify the increased cost of bipolar hemiarthroplasty in terms of reduced acetabular erosion in such patients [21]. We could not ascertain the use of expensive modular bipolar prosthesis over unipolar prosthesis when weighed against the benefits it offers. Moreover, the incidence of femoral neck fracture is on the rise worldwide, so the use of a relatively cheaper unipolar prosthesis in the elderly population may be justified, as the projected cost of savings would be substantial. Wathne has also argued that lower cost of unipolar prosthesis compared to a bipolar prosthesis is an additional indication of their use in community dwelling patients of >65 years of age [23]. Jia in 2015 performed a systematic review and metaanalysis of unipolar vs bipolar hemiarthroplasty in displaced femoral neck fractures. They found that bipolar hemiarthroplasty is more expensive without any added advantage in terms of postoperative outcome and long term rate of acetabular erosion [29]. Yang also performed a similar study and concluded that unipolar hemiarthroplasty is a more economical surgery [30].

Pot-operative hip dislocation

Literature shows that the rate of dislocation in a unipolar hemiarthroplasty can be upto 10% [31]. The risk of pot-operative hip dislocation has been shown to be lower in case of bipolar hemiarthroplasty, theoretically by virtue of its self-centering mechanism [32]. In our study there was no post-operative hip dislocation in either group. We could not find an exact explanation for this in our study.

This study's prospective design offered two specific advantages. First, all the patients followed a similar postoperative rehabilitative protocol that consisted of early mobilization with weight-bearing as tolerated. The second advantage is that the intrinsic inconsistencies of the chart analysis are avoided by prospective data collection. Although limited to short-term follow-up, our findings support the claim that bipolar prosthesis provides no added advantage over unipolar prosthesis when it comes to comparing functional outcome in terms of Harris Hip Score. AT the same time our study shows that cost of treatment with unipolar hip prosthesis is lower compared to bipolar hip prosthesis, which becomes significant when it comes to management of femoral neck fractures in elderly in resource limited areas. Owing to relatively short period of follow it is difficult to make a conclusive remark on the rate of acetabular erosion in the unipolar vs bipolar hemiarthroplasty. Besides the present study uses Harris Hip score as functional outcome evaluation tool, which has high validity and reliability for hip outcome evaluation in patients undergoing hip arthroplasty [33]. The combined use of Harris Hip score for functional outcome and radiological evaluation for acetabular erosion in our study is exactly the same as done by other authors in similar studies comparing the outcome of unipolar vs bipolar hemiarthroplasty of hip [21]. The limitation of our study is that the follow-up period is not long enough as longer follow up period is required to determine the rate of acetabular erosion and revision surgery. Being a single centre study and unblinded

observer used for assessment of functional outcome were other limitations of the present study.

Disclosure of conflict of interest

None.

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