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Original Article

Total hip replacement versus bipolar femoral head replacement for femoral neck fractures in the elderly: effect on surgical indices, hip function, and postoperative complications

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Abstract: Objective: To comparatively assess the effects of total hip replacement (THA) versus bipolar femoral head replacement (BFHR) on surgical indices, hip function, and postoperative complications (POCs) in elderly patients with femoral neck fractures (FNFs). Methods: A total of 135 elderly patients with FNF were enrolled and assigned to a BFHR group (n=65) receiving BFHR and a THA group (n=70) undergoing THA. Comparative analyses were conducted on surgical indices, postoperative recovery, Harris Hip scale, Barthel index, stress-related biomarkers, inflammatory markers, incidence of POCs, and quality of life (Generic Quality of Life Inventory-74 [GQOLI-74]). Results: Compared to the BFHR group, the THA group exhibited significantly higher values in several surgery- and recovery-associated indices. THA-treated patients achieved higher postoperative Harris Hip scores, Barthel Index scores, and GQOLI-74 scores. Additionally, stress- and inflammation-related indices, as well as the overall incidence of POC, were markedly reduced in the THA group. Conclusion: BFHR is characterized by minimal invasiveness, shorter operative time, and rapid postoperative recovery in FNF treatment among the elderly. In contrast, THA demonstrates superior clinical advantages in improving hip joint function, activities of daily living, and quality of life, along with more effective inhibition of postoperative stress and inflammation, and a lower POC risk.

Keywords: Total hip replacement, bipolar femoral head replacement, femoral neck fractures in the elderly, surgical indices, hip function

Introduction

Femoral neck fractures (FNFs), a common type of hip fracture, occur predominantly in the elderly and are associated with a high risk of disability [1, 2]. According to statistics, the risk of hip fractures in the elderly is increasing and is projected to double between 2018 and 2050 [3]. Pain, hip joint dysfunction, and subsequent dependence on activities of daily living (ADL) following FNFs can lead to a significant deterioration in patients' quality of life (QoL) [4]. In addition, the long-term care demands imposed by these conditions place a heavy burden on families, society, and the healthcare system [5]. If not treated in a timely manner, FNFs may lead to complications such as avascular necrosis of the femoral head, increasing mortality risk [6]. According to the degree of displacement based on Garden classification, FNFs can be classified into four types, among which type III (complete fractures with partial displacement) and type IV (complete fractures with complete displacement) are classified as displaced fractures and constitute the primary indications for joint replacement [7].

Bipolar femoral head replacement (BFHR) and total hip replacement (THA) are commonly employed joint replacement procedures for elderly FNF patients. BFHR is a form of hemiarthroplasty in which only the diseased femoral head is replaced while the native acetabulum is preserved, whereas THA involves replacement of both the femoral head and the acetabulum [8]. BFHR, given that it is less traumatic than

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THA, is more suitable for elderly patients or those in poor physical condition [9]. THA, in contrast, is characterized by superior outcomes in reducing dislocation risk, accelerating hospital discharge, and lowering 90-day or 1-year mortality [10, 11].

Despite the widespread use of both procedures, their comparative clinical efficacy in elderly patients with FNFs remains to be fully elucidated. Therefore, this study aims to further verify the relative advantages of THA and BFHR in terms of surgical indices, hip function, and postoperative complications (POCs), in order to provide evidence about the clinical practice of geriatric FNFs.

Patients and methods

General information

This retrospective study included 135 elderly patients with FNF who were admitted to People's Hospital of Jianhu County between May 2023 and May 2025. Patient were allocated into two groups according to the surgical procedure: a THA group (n=70) and a BFHR group (n=65). Ethical approval was obtained from the Ethics Committee of People's Hospital of Jianhu County. Our study cohorts exhibited clinical comparability with no statistical differences in general information identified (P>0.05).

Case selection criteria

Inclusion criteria: diagnosis of FNF confirmed by imaging [12]; unilateral FNF (Gardenm III or IV) [13]; age between 60 and 80 years; first FNF onset; time from fracture to hospital admission ≤7 days; normal communication and cognitive abilities; and complete medical data.

Exclusion criteria: acetabular fracture or defects identified by preoperative hip joint X-rays or computed tomography (CT) three-dimensional reconstruction; concurrent severe fractures in other anatomic regions; severe organic diseases such as cardio-cerebrovascular diseases; history of severe infection or surgery within the past 3 months; severe osteoporosis; abnormal coagulation function or bleeding tendency; previous hip surgery history; fractures secondary to metabolic disorders; or surgical contraindications.

Treatment methods

BFHR group: patients were placed in the contralateral decubitus position, under general anesthesia combined with nerve block. The affected hip was elevated and maintained in a flexed position, followed by routine skin preparation and draping. A posterolateral approach was adopted, and a skin incision (~10-15 cm in length) was made on the lateral side along the posterior margin of the greater trochanter. The soft tissues were dissected layer by layer to expose the posterolateral structure of the hip joint. After severing and suspending the piriformis and external rotator muscle groups, the joint capsule was incised to expose the hip joint. The femoral head was removed using a bone rongeur, and the ligamentum teres remnants were excised. After trimming the fracture ends of the femoral neck, the proximal femoral canal was opened with a retractor and sequentially reamed. A suitable biological femoral stem prosthesis was implanted to achieve a stable fixation within the femoral cavity. Subsequently, the bipolar femoral head prosthesis was installed, and the hip joint was reduced. Joint stability and range of motion (ROM) were assessed intraoperatively. Finally, the joint capsule was sutured, and the insertion of the gluteus medius and external rotators was reconstructed. The incision was closed in layers, and a sterile dressing was applied.

THA group: The same patient positioning, anesthesia mode, and surgical approach were used as in the BFHR group. The skin and subcutaneous tissue were incised layer by layer, with attention paid to the protection of peripheral blood vessels and nerves. Following hip joint exposure, residual cartilage tissue in the acetabular fossa was thoroughly removed, and the acetabulum was reamed to a suitable shape. The acetabular prosthesis was then implanted and secured. Intraoperative C-arm fluoroscopy was used to confirm the position and orientation of the acetabular component, followed by insertion of the acetabular liner. The proximal femoral medullary cavity was subsequently prepared through sequential reaming and broaching. A trial prosthesis was inserted to evaluate joint stability and hip range of motion, including flexion, extension, and rotation. After confirmation, the trial prosthesis was removed, and the definitive prosthesis was installed and secured firmly in the femoral medullary cavity with special tools. The hip joint was reduced, and its stability and mobility were reassessed. Finally, the surgical site was irrigated with normal saline, and the incision was closed in layers, followed by application of sterile dressings.

The choice of surgical procedure was determined by the operating surgeon based on a comprehensive evaluation of patient-specific factors, including age, fracture type, acetabular status, and tolerance to general anesthesia. BFHR was preferentially performed in the elderly, as well as those with multiple comorbidities or poor surgical tolerance, while THA was recommended for relatively younger patients, individuals with higher functional demands, and those with an intact acetabular articular surface.

Outcome measures

Surgical indices: Intraoperative blood loss (IBL), procedural duration, and postoperative drainage volume were recorded for both groups.

Recovery status: Time to first postoperative ambulation, length of hospital stay, and prosthesis-related recovery time were documented to assess patients' recovery. Prosthesis-related recovery time was defined as the time point at which the patient was able to ambulate with full weight-bearing without pain, accompanied by radiographic evidence showing absence of progressive radiolucent lines around the prosthesis, no subsidence, or displacement.

Hip function [14]: Hip joint function was evaluated using the Harris Hip Score (HHS) before surgery and at 1 year postoperatively. The evaluation included pain, (reverse scoring: lighter pain corresponds to higher scores), function, deformity, and joint ROM. All domains were calculated by a percentile system, with elevated scores suggesting better hip joint function (except the pain dimension).

Activities of daily living (ADL) [15]: ADL was assessed at one year postoperatively using the Barthel Index. The total score is 100, with scores ≤60 indicating moderate-to-severe dysfunction, 61-90 indicating mild dysfunction, and >90 indicating independence in self-care. Higher scores reflect better functional independence.

Stress-related biomarkers: Fasting venous blood sampling (3 mL) were collected before surgery and 1 month following treatment. Serum was separated by centrifugation. Epinephrine (Epi) levels were determined using radioimmunoassay, and cortisol (Cor) levels were determined using electrochemiluminescence immunoassay.

Inflammatory markers: Serum levels of interleukin (IL)-6/8 and C-reactive protein (CRP) were measured before surgery and 1 month after surgery using enzyme-linked immunosorbent assay (ELISA).

Postoperative complications (POCs): The incidence of postoperative adverse reactions, including incision infection, prosthesis loosening, acetabular wear, and deep venous thrombosis (DVT) were recorded and compared between groups.

Quality of life (QoL) [16]: QoL was assessed before surgery and one month following the operation using the Generic Quality of Life Inventory-74 (GQOLI-74). This tool consists of 74 items across four dimensions, material life, as well as social, physical, and psychological functioning. Each domain is scored on a 0-100 scale, with higher scores indicating better QoL.

Statistical methods

Statistical analyses were conducted using SPSS version 22.0. Continuous variables were expressed as mean ± standard deviation ($\bar{x} \pm s$). Inter-group comparison was made using independent-samples t-tests, and intra-group comparison before and after operation was conducted using paired t-tests. Categorical variables were presented as frequencies and percentages [n (%)] and compared using the chi-square (χ^2) test. A two-tailed P value <0.05 was considered significant.

Results

Comparison of baseline characteristics

As shown in **Table 1**, baseline characteristics were comparable between the two groups, including sex, age, body mass index (BMI),

Table 1. Comparison of baseline data between the two groups

Data	BFHR group (n=65)	THA group (n=70)	χ^2/t	P
Sex			0.167	0.683
Male	33 (50.77)	38 (54.29)		
Female	32 (49.23)	32 (45.71)		
Age (years)	67.86±4.56	69.39±5.03	1.858	0.065
Body mass index (kg/m^2)	22.83±2.43	23.07±2.68	0.547	0.585
Fracture site			0.079	0.779
Left	35 (53.85)	36 (51.43)		
Right	30 (46.15)	34 (48.57)		
Anatomical classification			0.661	0.719
Subcapital fracture	22 (33.85)	20 (28.57)		
Transcervical fracture	32 (49.23)	35 (50.00)		
Basicervical fracture	11 (16.92)	15 (21.43)		
Garden classification			0.135	0.714
III	24 (36.92)	28 (40.00)		
IV	41 (63.08)	42 (60.00)		
Cause of injury			2.000	0.368
Fall from height	11 (16.92)	15 (21.43)		
Traffic accident	23 (35.38)	30 (42.86)		
Fall	31 (47.69)	25 (35.71)		

Note: THA, total hip replacement; BFHR, bipolar femoral head replacement.

Table 2. Comparison of surgical indicators between the two groups

Surgical index	BFHR group (n=65)	THA group (n=70)	t	P
Intraoperative blood loss (mL)	174.89±32.22	226.06±41.47	8.003	<0.001
Procedural duration (min)	95.89±13.14	116.06±19.67	6.979	<0.001
Postoperative drainage volume (mL)	142.94±23.28	175.10±32.45	6.601	<0.001

Note: THA, total hip replacement; BFHR, bipolar femoral head replacement.

Table 3. Comparison of postoperative recovery between the two groups

Surgical index	BFHR group (n=65)	THA group (n=70)	t	P
Time to initial postoperative ambulation (d)	5.71±2.50	7.80±3.50	3.983	<0.001
Hospital stay (d)	13.68±3.21	20.43±4.48	10.040	<0.001
Prosthesis healing time (d)	115.91±14.99	148.60±17.95	11.501	<0.001

Note: THA, total hip replacement; BFHR, bipolar femoral head replacement.

fracture site, anatomical classification, Garden classification, and cause of injury (all P>0.05).

Comparison of surgical indices

As shown in **Table 2**, significant differences were observed between the two groups in surgical indices (P<0.001). The THA group demonstrated greater IBL, longer operative time, and higher postoperative drainage volume compared to the BFHR group (P<0.001).

Comparison of postoperative recovery

As shown in **Table 3**, The THA group demonstrated significantly longer time to first ambulation, prolonged hospital stay, and extended recovery time, compared to the BFHR cohort (P<0.001).

Comparison of hip joint function

As shown in **Table 4**, no significant differences were observed between the two groups at

Table 4. Comparison of hip joint function between the two groups

Harris scale	BFHR group (n=65)	THA group (n=70)	t	P
Pain (points)				
Pre-operation	50.00±4.90	49.03±5.43	1.093	0.276
1 year post-operatively	75.91±7.56***	83.93±7.69***	6.145	<0.001
Functioning (points)				
Pre-operation	52.52±6.39	52.59±7.76	0.057	0.954
1 year post-operatively	77.40±7.04***	86.76±6.74***	7.947	<0.001
Deformities (points)				
Pre-operation	55.31±7.34	55.96±6.87	0.535	0.593
1 year post-operatively	74.02±6.76***	86.34±7.56***	10.012	<0.001
Joint range of motion (points)				
Pre-operation	55.89±5.92	54.44±7.18	1.282	0.202
1 year post-operatively	77.22±6.54***	87.33±6.73***	8.898	<0.001

Notes: ***P<0.001 vs. preoperative in the same group. THA, total hip replacement; BFHR, bipolar femoral head replacement.

Table 5. Comparison of daily living ability between the two groups

Activity of daily living	BFHR group (n=65)	THA group (n=70)	Z	P
Moderate-to-severe dysfunction	5 (7.69)	1 (1.43)	-3.588	<0.001
Mild dysfunction	46 (70.77)	42 (60.00)		
Self-care	14 (21.54)	27 (38.57)		

Note: THA, total hip replacement; BFHR, bipolar femoral head replacement.

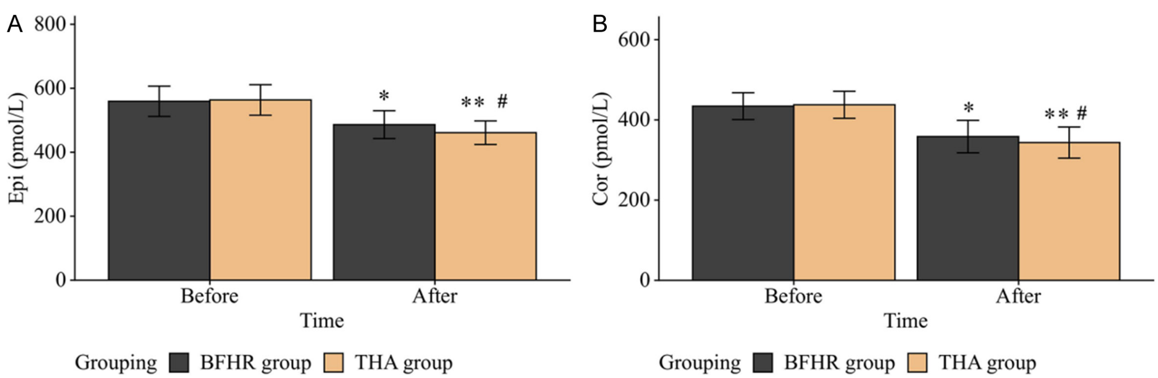

Figure 1. Comparison of stress-related markers between the two groups. A. Comparison of Epi levels between the two groups before and after treatment; B. Comparison of Cor levels between the two groups before and after treatment. Note: *P<0.05, **P<0.01, vs. the preoperative level within the group; #P<0.05 vs. BFHR group at the identical time point. Epi, epinephrine; Cor, cortisol; THA, total hip replacement; BFHR, bipolar femoral head replacement.

baseline in terms of pain, function, deformity, and joint ROM (P>0.05). At one year postoperatively, both groups exhibited significant improvements across all domains (all P<0.001), with the THA group demonstrating significantly greater improvements than the BFHR group (all P<0.001).

Comparison of ADL

As shown in **Table 5**, the Barthel Index scores at 1 year postoperatively were significantly higher in the THA group than in the BFHR group (P<0.001), indicating better recovery of ADL.

Comparison of stress-related markers

As shown in **Figure 1**, there were no significant differences in Epi or Cor levels between the two groups before operation (P>0.05). At one month post-operatively, Epi and Cor levels were markedly reduced in both groups (P<0.05), with greater reductions in the THA group compared to the BFHR group (P<0.05).

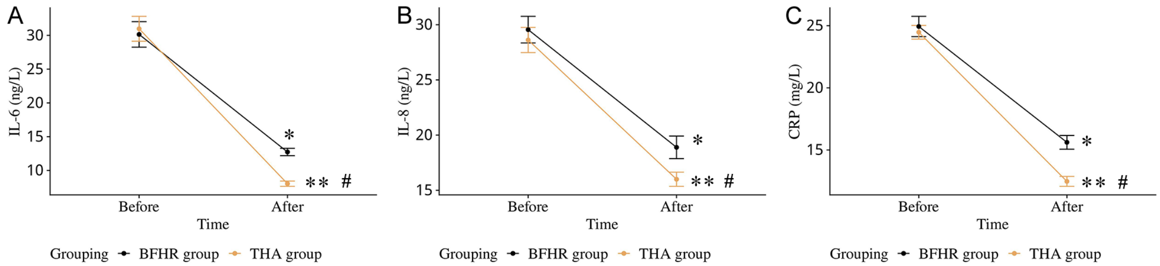

Figure 2. Comparison of inflammatory factors between the two groups. A. Comparison of IL-6 levels between the two groups before and after treatment; B. Comparison of IL-8 levels between the two groups before and after treatment; C. Comparison of CRP levels between the two groups before and after treatment. Note: *P<0.05, **P<0.01, *vs.* the preoperative level within the group; #P<0.05 *vs.* BFHR group at the identical time point. IL, interleukin; CRP, C-reactive protein; THA, total hip replacement; BFHR, bipolar femoral head replacement.

Table 6. Comparison of the incidence of postoperative complications between the two groups

Postoperative complication	BFHR group (n=65)	THA group (n=70)	Fisher's	P
Incision infection	2 (3.08)	0 (0.00)		
Prosthesis loosening	5 (7.69)	1 (1.43)		
Acetabular wear	2 (3.08)	1 (1.43)		
Deep venous thrombosis	2 (3.08)	2 (2.86)		
Total	11 (16.92)	4 (5.71)		0.054

Note: THA, total hip replacement; BFHR, bipolar femoral head replacement.

Comparison of inflammatory markers

As shown in **Figure 2**, there were no significant differences in preoperative IL-6, IL-8, and CRP levels between the two groups (P>0.05). At one month post-operatively, all these inflammatory markers were significantly reduced in both groups (P<0.05), with significantly lower levels observed in the THA group compared to the BFHR group (P<0.05).

Comparison of POC

POCs, including incision infection, prosthesis loosening, acetabular wear, and DVT, occurred in 5.71% of the patients in the THA group and 16.92% in the BFHR group (**Table 6**), showing no marked between-group difference (P=0.054).

Comparison of QoL

The GQOLI-74-based QoL assessment (**Table 7**) revealed comparable preoperative scores between groups (P>0.05). At one month postoperatively, QoL scores in all dimensions significantly increased in both groups (P<0.05), with the THA group showing significantly greater improvement compared to the BFHR group (P<0.05).

Discussion

This study confirmed the distinct characteristics of THA and BFHR in the management of FNFs among the elderly. THA was associated with superior long-term outcomes, including improved hip joint function, ADL, and QoL at one year after the operation, as well as more pronounced reductions in stress and inflammatory responses. In contrast, BFHR is characterized by lower surgical risk and quick postoperative recovery. These findings may provide valuable evidence to guide surgical decision-making and optimize clinical management in this patient population.

In this study, the THA group exhibited significantly greater IBL, longer procedural duration, and higher postoperative drainage volume, indicating increased surgical invasiveness compared to BFHR. In contrast, BFHR is technically less complex and associated with reduced operative trauma, thereby contributing to lower IBL and shorter procedural duration [17]. THA requires both femoral and acetabular reconstruction, making the procedure more technically demanding and potentially increasing operative time, blood loss, and perioperative stress [18]. Our findings are consistent with previous reports. For instance, Shi et al. [19]

Table 7. Comparison of quality of life between the two groups

GQOLI-74 scale	BFHR group (n=65)	THA group (n=70)	t	P
Material life (points)				
Pre-operation	57.14±3.97	56.67±5.42	0.574	0.567
1 year post-operatively	74.17±6.84***	84.56±7.53***	8.421	<0.001
Social functioning (points)				
Pre-operation	61.40±4.53	60.34±5.59	0.146	0.884
1 year post-operatively	75.65±6.89***	84.19±6.17***	7.654	<0.001
Physical functioning (points)				
Pre-operation	60.52±5.57	62.16±7.28	1.469	0.144
1 year post-operatively	72.03±6.56***	84.23±6.79***	10.671	<0.001
Psychological functioning				
Pre-operation	62.26±4.94	62.10±4.85	0.191	0.849
1 year post-operatively	74.80±6.65***	84.73±6.97***	8.510	<0.001

Note: ***P<0.001 vs. preoperative within the group. THA, total hip replacement; BFHR, bipolar femoral head replacement; GQOLI-74, Generic Quality of Life Inventory-74.

demonstrated that BFHR was associated with shorter operative time and less intraoperative bleeding compared with internal proximal femur locking plate fixation for femoral intertrochanteric fractures. Similarly, Li et al. [20] reported that elderly patients undergoing BFHR achieved earlier mobilization and shorter bed rest duration than those treated with other fixation methods, supporting the advantage of BFHR in early postoperative recovery. From the perspective of postoperative recovery, THA approach required a longer time to first postoperative ambulation, had extended hospital stays, and exhibited delayed functional recovery compared to the BFHR technique. This may be attributed to the greater surgical trauma and physiological stress associated with THA.

When evaluating hip joint function, THA demonstrated superiority over BFHR in promoting hip functional recovery at one year post-operation among elderly FNF patients. This may be attributed to the fact that THA, though with greater operational challenge, carries a relatively low postoperative risk of hip joint dislocation and revision, which is conducive to the smooth recovery of the patient's long-term hip joint function [21]. Consistent with our findings, Liu et al. [22] reported that THA was more effective than BFHR in improving hip joint function in patients with intertrochanteric fractures. Furthermore, ADL evaluation revealed that THA was more beneficial in improving functional independence of elderly FNF patients.

Regarding stress-related biomarkers (Epi, Cor) and inflammatory markers (IL-6, IL-8, CRP), THA was associated with more greater reductions compared with BFHR, suggesting a more pronounced attenuation of postoperative stress and inflammatory responses, aligning with previous findings [23]. One possible explanation is that THA involves more comprehensive debridement of degenerated cartilage and hyperplastic/pathological synovial tissue, which may help reduce local inflammatory stimuli and improve the intra-articular microenvironment [24]. In contrast, BFHR preserves the original acetabulum, resulting in suboptimal load distribution and increased mechanical wear at the prosthesis-acetabulum interface. This may contribute to chronic synovial irritation and subsequent inflammatory responses, potentially increasing the risk of prosthesis loosening and compromising long-term joint stability [25].

Safety evaluation revealed a comparable incidence of postoperative POCs between the two approaches, including incision infection, prosthesis loosening, acetabular wear, and DVT. Furthermore, THA demonstrated superiority over BFHR in improving patients' QoL at one year postoperatively. Previous studies have reported that THA may be more effective than monopolar femoral head replacement in improve QoL in patients with femoral neck fractures, especially for patients younger than 80 years and with fewer complications, which is consistent with our findings [26]. In the study of

Wang et al. [27], BFHR was associated with lower treatment costs compared to THA in elderly FNF patients, complementing our observations.

Based on these findings, the selection between THA and BFHR should be individualized, considering patient-specific factors such as age, general health condition, surgical tolerance, life expectancy, functional demands, and patient and family expectations, as well as institutional expertise. BFHR may be preferred in older patients with poor general condition or limited surgical tolerance. For those with overall good health status, longer life expectancy, higher functional demands, or concomitant hip joint diseases, THA is more preferred as it provides superior long-term functional outcomes and improved QoL [28].

This study has several limitations that should be acknowledged. First, the follow-up duration was relatively short, which may have limited the assessment of long-term efficacy and prognosis. Future studies with extended follow-up periods (e.g., ≥3 years) are warranted to better evaluate long-term efficacy and prognosis of the two therapies. Second, economic benefits were not assessed in this study. Relevant data, including operative costs, hospitalization expenses, and postoperative rehabilitation costs, should be incorporated in future analyses to provide more comprehensive evidence for clinical decision-making and optimal allocation of medical resources. Third, subgroup analyses were not performed. Stratified analyses based on factors such as sex, age, anatomic classification, and Garden classification are needed to further clarify the differential benefits of THA and BFHR in specific patient populations.

Conclusion

THA provides superior long-term benefits in elderly patients with FNFs, specifically in improving hip joint function, activities of daily living, and quality of life. However, it also was associated with increased intraoperative bleeding and postoperative drainage, loner procedural duration, and delayed early postoperative recovery, including prolonged time to postoperative ambulation and extended hospital delay. The choice between THA and BFHR should be individualized based on patient characteristics and clinical conditions.

Disclosure of conflict of interest

None.

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