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ORIGINAL RESEARCH

Superpath is Superior to Posterolateral Approach for Hemiarthroplasty in Geriatric Patients with High Risk for Dislocation

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Background: Dislocation following hemiarthroplasty (HA) for femoral neck fractures in the elderly was a rare but severe complication. Tissue-sparing SuperPATH approach for HA had been described with promising results in terms of function recovery, transfusion and dislocation rate. The aim of the present study was to investigate the clinical outcomes, perioperative complications, and mortality rate through SuperPATH (SP) and posterolateral (PL) approach in geriatric patients with high dislocation risk.

Methods: A total of 621 patients from January 2015 to January 2024 were retrospectively reviewed. According to high-dislocated risk, 39 patients through SuperPATH approach and 42 patients through posterolateral approach met the inclusion criteria. All the surgeries were performed by the same hip surgery team. The operation time, surgery incision, intraoperative blood loss and complications were evaluated. The postoperative outcomes, especially dislocation and mortality were assessed at 1-month, 6-month, and 1-year follow-up intervals postoperatively.

Results: Compared with PL group, the surgery incision and blood transfusion rate in SP group was significantly decreased. The early Harris hip score in SP group was significantly higher than that of PL group ($t = 7.587$, $p < 0.001$) at 1-week postoperatively, without statistic difference at one month and one year. Totally, the one-year mortality for all patients with high risk of dislocation was 18/81 (22.22%). 8 patients sustained one or more dislocations in PL group, while no patients in the SP group did (OR = 1.235, p = 0.004). The incidence of reoperation was significantly lower in SP group. While there was no significant difference of complication and one-year mortality between groups.

Conclusion: SuperPATH approach for bipolar HA was associated with reducing dislocation and accelerating early hip function recovery in high-risk dislocation population. Once predictors of dislocation risk following HA in the elderly were detected, tissue-sparing invasive approach or constrained THA prosthesis might be considered to avoid evitable complications.

Keywords: geriatric patients, femoral neck fracture, hemiarthroplasty, SuperPATH approach, high dislocation risk

Introduction

Gradually increasing incidence of hip fractures is a major cause of disability and mortality in geriatric population.[1–3] The choice of hemiarthroplasty (HA) versus total hip arthroplasty (THA) is a debated topic. Definitely, the bipolar HA is chosen by major surgeons as the standard surgical procedure for elderly patients with displaced femoral neck fracture (FNF) due to its relatively lower surgical time, blood loss and dislocation rate. Considering the limited life expectancy and functional requirement,[4] HA is specifically indicated in elderly patients for lower surgical trauma and perioperative complications.

Dislocation, as a relatively rare but severe complication, still turns out to be the most common reason for the reoperation after HA.[5] In view of elderly patients' frailty and frequent multiple comorbidities, dislocation is associated with increased

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morbidity, hospitalization length and financial cost.[6,7] Several studies[8–10] indicated that neuromuscular diseases, cognitive comorbidities and dysplastic morphology of acetabulum are recognized as high risk factors for HA. However, few studies specially referred to the clinical outcomes and morbidity of the HA in geriatric patients with high risk of dislocation.

Considered of accelerating early hip recovery, orthopedic surgeons have been devoted to improving surgical techniques and procedures for avoidable trauma and complication perioperatively. Posterolateral approach, as the conventional and most commonly used surgery approach, has its advantage of surgical exposure and revision procedure. However, imbalance of hip muscle tendon leads to high tendency for posterior dislocation and early functional motivation, especially in high-risk dislocation population.[9] Over the past decade, tissue-sparing minimally invasive approaches for hip arthroplasty have been described to encourage early mobilization and decrease perioperative complications. As part of this endeavor, James Chow[11] introduced the Supercapsular percutaneously assisted approach (SuperPATH), which was gradually described with promising results in terms of hospitalization length, blood loss and dislocation rate than conventional posterolateral approach.[12] Unlike total hip arthroplasty, only a few studies[13,14] have focused on the clinical outcomes of SuperPATH hemiarthroplasty. Thus, we hypothesized that SuperPATH for HA might be associated with lower rates of dislocation and reoperation.

In this study, the research questions were: (1) what are the clinical outcomes, perioperative complications, and mortality rate of HA in geriatric patients with high dislocation risk? (2) what are the differences of dislocation incidence and functional recovery of HA through SuperPATH (SP) and posterolateral (PL) approach in geriatric patients with high dislocation risk.

Materials and Methods

Study Design and Patients

The study was approved by the institutional review board of Guangdong Provincial People's Hospital and Guangdong Provincial People's Hospital Ganzhou Hospital. We retrospectively reviewed 621 patients treated with bipolar hemiarthroplasty for unilateral femoral neck fracture from January 2015 to January 2024. All patients were older than 70 years old and received a minimum follow-up of at least 1 years regularly. Patients suffered from pathological fractures, trochanteric fractures, previous hip fractures, hip infection or surgery history, and less than 1-year follow-up were excluded. In addition, patients without standard preoperative radiographs, computed tomography (CT) and postoperative radiographs were also excluded. The study was approved by the institutional review board of Guangdong Provincial People's Hospital (IRB: KY2024-363-01) and Ganzhou Hospital (IRB: SKJJ2024008H).

Regarding the previous analyses of dislocation after HA,[9,15–17] high-risk factors include neuro-cognitive impairment dysfunction and morphological features, which were summarized in Table 1. Neuro-cognitive impairment dysfunction was determined by the diagnostic criteria[18] of neurocognitive disorders in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). The motor function of patients with neuromuscular disease was diagnosed and evaluated by the NM-Score.[19] According to the anteroposterior pelvic radiographs,[10,15] Cup-CE angle and acetabular depth-to-width ratio were measured. According to CT images,[20,21] an intercapital center line (ICL) was drawn on true axial images through both femoral heads at the point of the largest diameter in all 3 planes. Thus, an orthogonal line to the ICL the ICL90 was drawn. The posterior acetabular sector angle (PASA) was determined as the angle between the ICL and a line from the femoral head center to the lateral edge of the posterior wall. The PWA was determined as the angle between the ICL90 and the tangent to the

Table 1 Dislocation Risk Factors

Category	Risk Factors
Neuromuscular disease	Parkinson's disease, epilepsy, post-stroke sequelae, polio sequelae
Cognitive dysfunction	Dementia, Alzheimer's disease
Posterior wall defect	PASA<90°, PWA<70°
Cup-CE angle	<40°
ADWR	<0.28

Abbreviations: PASA, posterior acetabular sector angle; PWA, posterior wall angle; Cup-CE angle, Cup-center edge angle; ADWR, Acetabular depth-to-width ratio.

posterior articular surface area. According to the previous report,[17] the posterior wall defect was defined as both PASA < 90° and PWA < 70°simultaneously, which was associated with a higher risk for HA dislocation. Accordingly, all the high-risk dislocation participants were identified with at least two dependent risk factors for dislocation.

Totally, 81 patients were identified as having a high risk of dislocation (at least two dependent risk factors) and finished 1-year follow-up. Accordingly, the SuperPATH technique was performed regularly and become the primary surgical method for HA in our institution in 2019. Based on the surgery approach, 39 patients through SuperPATH (SP) approach and 42 patients through posterolateral (PL) approach were finally enrolled (Figure 1). All the surgeries were performed by the same hip surgery team. Demographic features were retrospectively retrieved from the database of our hospital. American Society of Anesthesiologists (ASA) was calculated to obtain an overall assessment of the preoperative comorbid condition.[22]

Surgical Procedure

All the surgical operations were performed in the lateral decubitus position, followed by standard surgical field exposure and hemiarthroplasty implantation. Through posterolateral approach, the hip joint capsule was preserved and sutured in all cases. Further, short external rotator tendons and posterior joint capsules were also repaired onto the femur in all cases. Through SuperPATH approach, both gluteus and external rotator tendons were fully preserved. After implantation, the capsule was intactly sutured and gluteus and external rotator tendons restored to their anatomic positions after removing the retractors (Figure 2). Routinely, post-operative drain was not used in both HA groups.

Postoperative Management and Follow-up

After surgery, standard hip anteroposterior and lateral radiographs were taken. Full weight-bearing and active mobilization were allowed within 48 hours postoperatively. All patients were advised to avoid >90°of flexion, excessive adduction, and excessive internal rotation in hip mobilization. The operation time, intraoperative blood loss, transfusion and complications were evaluated between the two groups. The intraoperative and postoperative complications included periprosthetic fracture, deep vein thrombosis, dislocation, deep infection, reoperation. The postoperative outcomes were assessed at 1-month, 6-month, and 1-year follow-up intervals after the operation.

In terms of the high risk of dislocation, managements and operative interventions for each dislocated hemiarthroplasty and subsequent dislocations were recorded. All surviving patients were reviewed either in our outpatient clinic or by

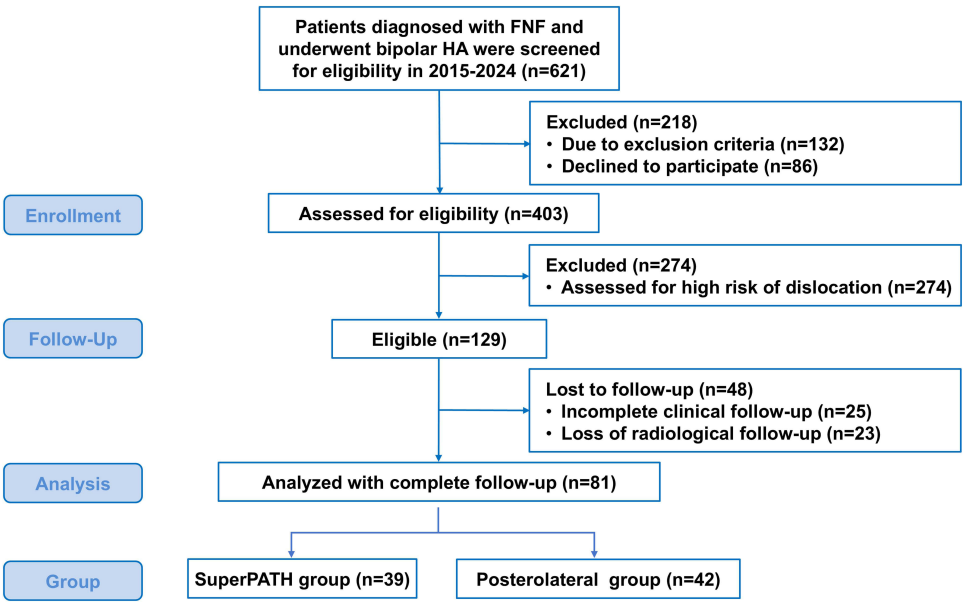

Figure 1 Patient selection flowchart.
Abbreviations: FNF, femoral neck fracture; HA, hemiarthroplasty.

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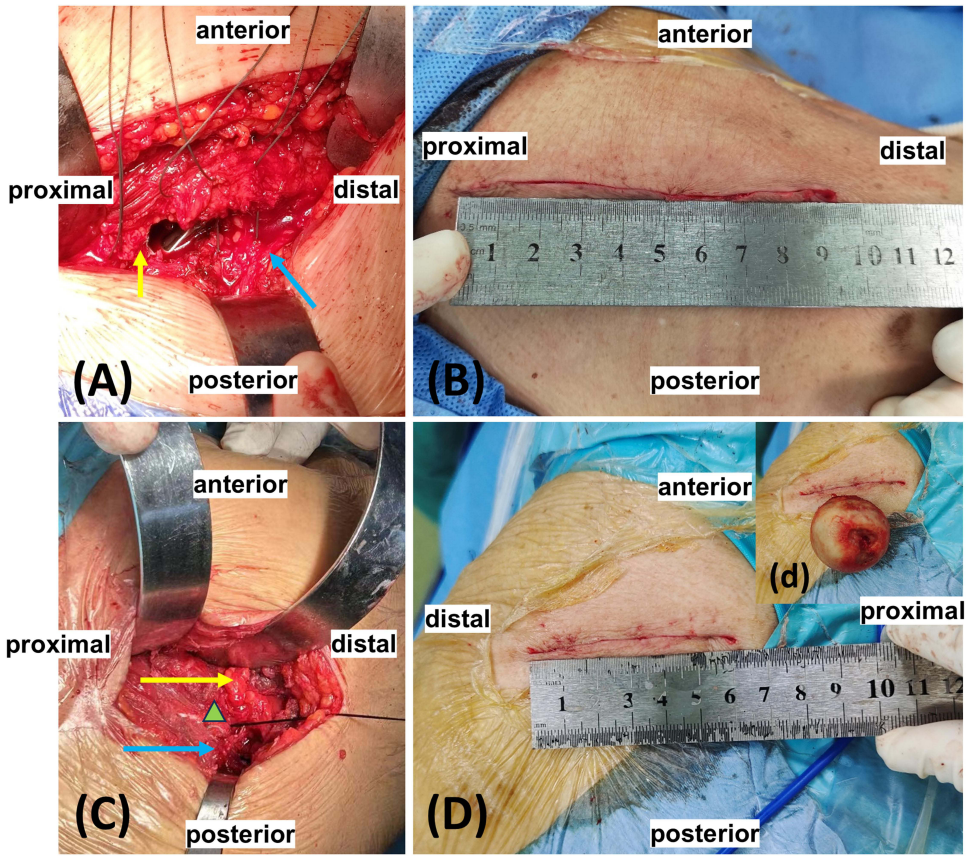

Figure 2 Intraoperative images of hemiarthroplasty in PL and SP groups. (**A**) Through posterolateral approach, short external rotator tendons (blue arrow) and posterior joint capsules (yellow arrow) were repaired; (**B**) Skin incision through posterolateral approach; (**C**) Through SuperPATH approach, both gluteus (yellow arrow) and external rotator tendons (blue arrow) were fully preserved and restored to their anatomic positions after suturing of capsule (green triangle); (**D**) Skin incision through SuperPATH approach; (d) Minimally invasive incision was slightly longer than femoral head.

a telephone assessment of pain and function, along with whether the patient had required further surgery within one year of hemiarthroplasty. Death within one year of operation formed the outcome measures of this study.

Statistical Analysis

All statistical analyses were performed using SPSS version 21.0 (SPSS, Chicago, IL, USA). Continuous variables were reported with mean ± standard deviation (SD), while categorical variables were presented as number (n) and percentage (%). Group comparisons for quantitative data were performed using Student's independent sample *t*-tests, and categorical data were compared using the chi-squared test. To confirm the effectiveness of the tests, a post-hoc power calculation was determined by the statistical power analyses G Power 3.1 to eliminate type II error. The effect sizes for the *t*-test and Chi-square test are Cohen's d and Cohen's w, respectively, with a type I error (α) of 0.05.

A univariate logistic regression was used to estimate the odds ratio (OR) of dichotomous outcomes (dislocation/complication/reoperation/mortality) between SP and PL groups (PL group as reference). The Kaplan–Meier survival analysis was used to compare the patient's one-year mortality between groups; an univariate Cox proportional-hazard regression was used to estimate the Hazard Ratio (HR) between SP and PL groups (PL group as reference). A P value less than 0.05 was statistically significant.

Results

During the inclusion period, 39 patients through SuperPATH approach and 42 patients through posterolateral approach were finally enrolled in this present study. At least two dependent risk factors for dislocation (67% had three or more) were present in each case. Accordingly, the demographic and preoperative data were comparable between SP and PL groups, with no

significant difference. (Table 2). In addition, both operative time and perioperative hemoglobin reduction had no significant difference. However, the blood transfusion rate (12.82% vs 35.71%, $p < 0.05$) and surgery incision length were significantly decreased in the SP group. In terms of the hip function, the 1-week postoperative HHS in SP group was significantly better than that of PL group ($t = 7.587$, $p < 0.001$), while the differences were not statistically significant at one month and one year postoperatively. Post-hoc power analysis showed a power >0.97 for detecting a significant difference.

According to the follow-up, 8 patients sustained one or more dislocations in PL group, while no patients in the SP group did (OR = 0.051, p = 0.004, PL group as reference), as listed in Table 3. Totally, the incidence of dislocation was 9.88% (8 of 81 hips) in high-risk population. The median time from bipolar hemiarthroplasty to the first incident of dislocation was 13.86 (range, 1–37) days. All the patients were initially treated by closed reduction under anesthesia in the operating theatre, for whom this was successful on 6 occasions (Figure 3A–C). Of the other two cases, one patient required an open reduction and required no further treatment, while the other one recognized as bipolar dissociation accepted a revision THA. Three patients required no further treatment after a single closed reduction. Considered the other three cases, two patients experienced a second dislocation and both accepted a revision THA. While the last one who refused a revision procedure, suffered three dislocations, finally died within 2 months after the hemiarthroplasty.

In PL group, one patient suffered from periprosthetic joint infection (PJI) within two weeks operatively, subsequently she was performed by a successful debridement, antibiotics and implant retention (DAIR). One patient experienced superficial infection in SP group was managed with antibiotic therapy. There were two patients suffered from periprosthetic fracture postoperatively (both are Vancouver A1 postoperatively), both of whom accepted tension-band internal fixation (Figure 3D–F). Including the dislocation, there was no significant difference of complication between two groups. However, the incidence of reoperation was significantly lower in SP group (OR = 0.198, $P < 0.05$).

Table 2 Demographic and Perioperative Data

	SP Group (n=39)	PL Group (n=42)	t/χ^2 value	P value
Age (y)	82.56±7.48	80.43±7.15	−1.313	0.193
BMI (m/kg2)	26.32±4.18	26.92±3.92	−0.673	0.503
ASA	2.67±0.74	2.74±0.80	−0.417	0.678
Gender (Male/female)			0.480	0.488
Male	12 (30.77%)	16 (38.10%)		
Female	27 (69.23%)	26 (61.90%)		
Side (Left/Right)			0.080	0.777
Left	22 (56.41%)	25 (59.52%)		
Right	17 (43.59%)	17 (40.48%)		
Neuromuscular disease (Yes/No)			0.223	0.637
Yes	12 (30.77%)	15 (35.71%)		
No	27 (69.23%)	27 (64.29%)		
Cognitive dysfunction (Yes/No)			0.010	0.921
Yes	19 (48.72%)	20 (47.62%)		
No	20 (51.28%)	22 (52.38%)		
Operative time (min)	79.36±13.87	76.90±11.04	0.884	0.379
surgery incision (cm)	6.78±0.71	9.96±1.24	14.262	<0.001**
Preoperative Hb (g/L)	101.38±11.09	103.67±16.80	−0.726	0.47
3-day Hb Difference (g/L)	20.26±9.81	20.17±10.62	0.039	0.969
Transfusions (Yes/No)			5.700	0.017*
Yes	5 (12.82%)	15 (35.71%)		
No	34 (87.18%)	27 (64.29%)		
Preoperative HHS	11.97±0.86	11.76±0.53	1.327	0.189
1-week postoperative HHS	55.22±4.99	46.03±5.83	7.587	<0.001**
1-month postoperative HHS	73.69±4.91	71.26±11.46	1.256	0.214
1-year postoperative HHS	88.34±3.65	86.61±4.22	−1.744	0.086

Notes: Values are expressed as the mean and the standard deviation; *p < 0.05, ** p < 0.01.
Abbreviations: HHS, Hip Harris Score; 3-day Hb Difference, 3-day postoperative Hb- preoperative Hb.

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Table 3 Comparison of Dislocation, Complications and One-year Mortality

	SP Group (n=39)	PL Group (n=42)	OR (95% CI)	χ^2 value	P value
Dislocation			0.051 (0.003–0.923) [a]	8.243	0.004**
Yes	0 (0%)	8 (19.05%)			
No	39 (100%)	34 (80.95%)			
Complication			0.306 (0.076–1.226)	3.023	0.082
Yes	3 (7.69%)	9 (21.43%)			
No	36 (92.31%)	33 (78.57%)			
Reoperation			0.198 (0.040–0.984)	4.578	0.032*
Yes	2 (5.13%)	9 (21.43%)			
No	37 (94.87%)	33 (78.57%)			
One-year mortality			0.616 (0.212–1.795)	0.795	0.373
Yes	7 (17.95%)	11 (26.19%)			
No	32 (82.05%)	31 (73.81%)			

Notes: Values are expressed as the mean and the standard deviation; *p < 0.05, ** p < 0.01. [a]Since the SP group has no cases of dislocation (0 case), the formula for calculating the odds ratio cannot be directly applied. Therefore, the Haldane-Anscombe correction is used, which involves adding 0.5 to each value in the 2×2 table before estimating the odds ratio.

Totally, the one-year mortality for all patients with high risk of dislocation was 18/81 (22.22%), with 7/39 (17.95%) in SP and 11/42 (26.19%) in PL group, respectively. Among the 11 patients in PL group, 4 patients experienced one or more dislocations. After considering survival time (overall survival days), the hazard ratio (HR) for the SP group relative to the PL group was 0.619 (95% CI: 0.204–1.598, P = 0.322), and the Kaplan-Meier result (Figure 4) also showed that

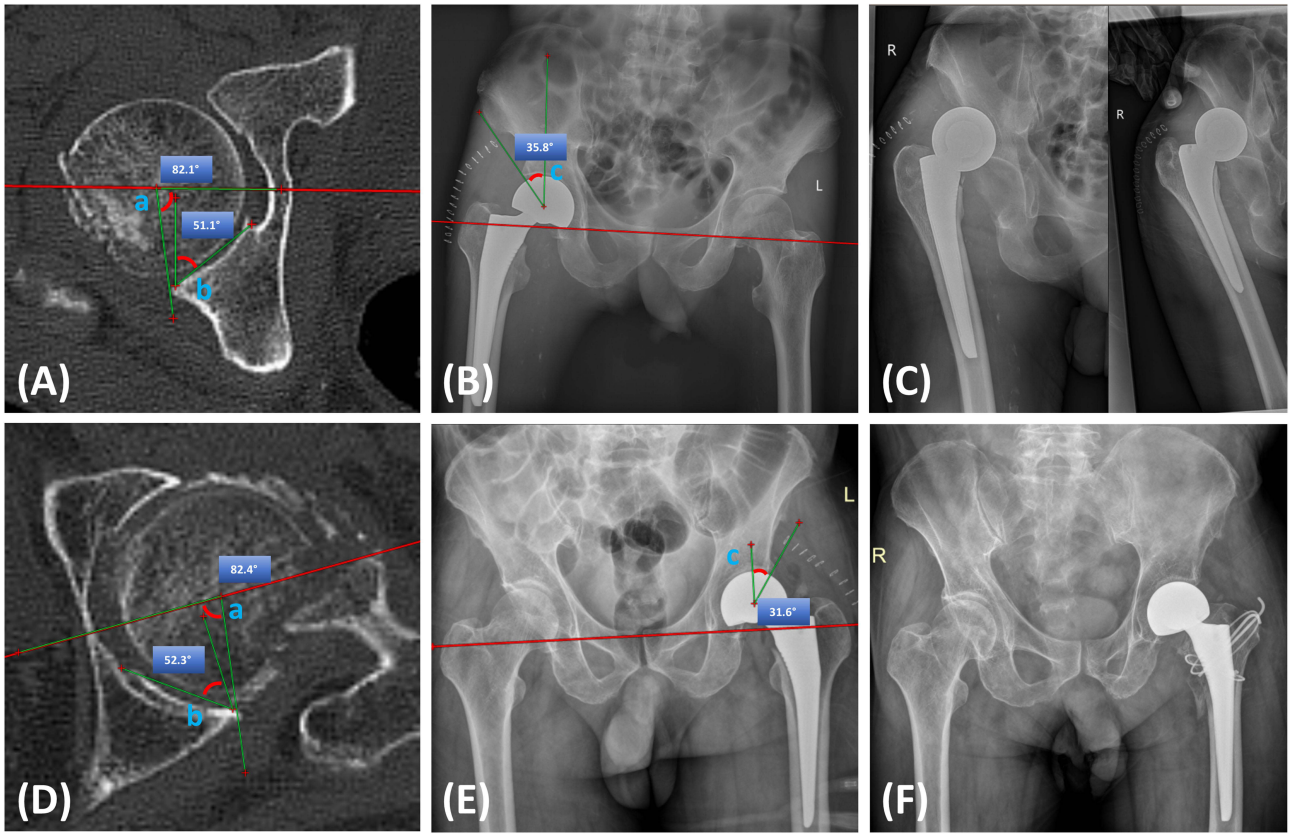

Figure 3 Typical cases in PL and SP groups. An 86-year-old female patient in PL group; (**A**) preoperative Hip CT images: PASA (a)=82.1°, PWA (b)=52.1°; (**B**) postoperative anteroposterior X-ray radiographs: Cup-CE angle=35.8°; (**C**) She suffered three postoperative dislocations treated with close reduction; A 77-year-old male patient in SP group; (**D**) preoperative hip CT images: PASA (a)=82.4°, PWA (b)=52.3°; (**E**) postoperative anteroposterior X-ray radiographs: Cup-CE angle=31.6°; (**F**) He suffered periprosthetic fracture 6 months postoperatively caused by fall injury and treated with tension-band internal fixation.

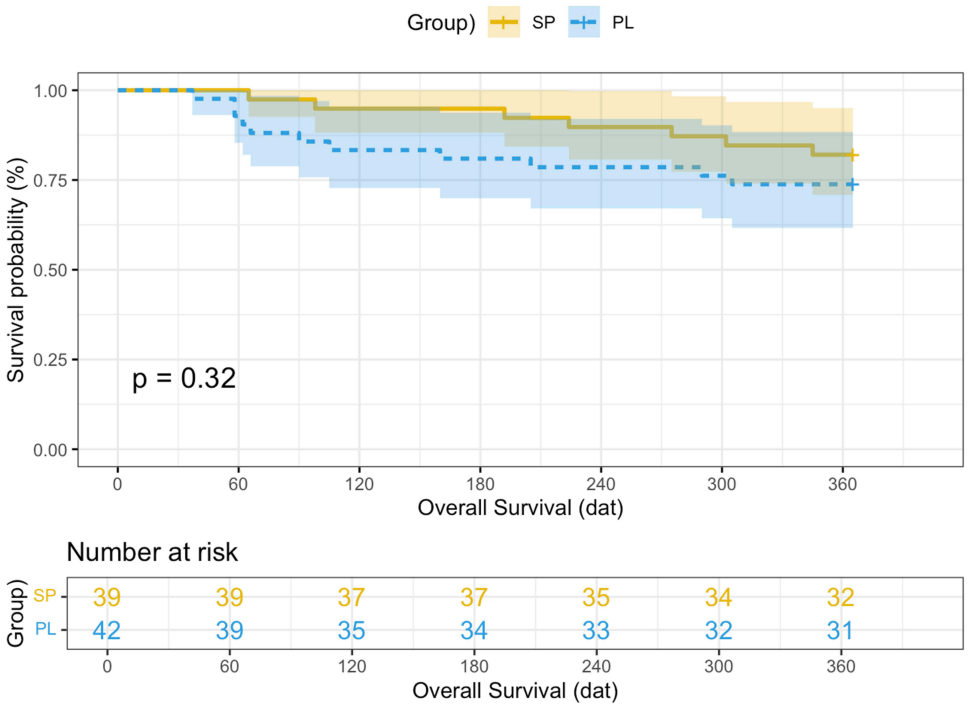

Figure 4 Kaplan-Meier survival curve comparing mortality up to one-year post-primary hemiarthroplasty by PL and PS groups. Dotted lines represent upper and lower confidence intervals.

although there were no significant differences between the two groups (Log rank test, P=0.322), the overall survival trend for the SP group was descriptively higher than that for the PL group.

Discussion

The bipolar hemiarthroplasty has been widely used to treat displaced femoral neck fractures in elderly patients, providing pain relief, functional improvement, and low revision rate. Thus, dislocation after HA is a relatively uncommon but devastating complication.[5,23] As far as we know, this is the first report to present the clinical outcomes and complications of HA in the geriatric population with high dislocation risk. Comparatively, the SuperPATH approach in patients with FNF assures improving early-time mobilization, lower transfusion rate, as well as reducing dislocation and reoperation incidence after hemiarthroplasty.

Surgeons attempt to elucidate the risk factors for dislocation of HA for improving clinical outcomes in the geriatric population.[9,16,24] Accordingly, risk factors can be categorized into patient-related, surgical, and morphological factors. Cognitive impairment or neuromuscular disorders definitely lead to the hip imbalance and inadequate muscle tension in geriatric patients, which was strongly recognized as patient-related risk of dislocation after HA.[25–28] Huo et al[29] suggested THA with constrained liner instead of HA in such high-risk patients. The surgical factors such as surgical approach, prosthesis type or uncemented vs cemented implant were mentioned previously. Except for approach, there is a lack of consistent conclusions and conclusive evidence. Regarding the morphological factor,[8,17] parameters related to hip dysplasia and a shallow acetabulum were determined as independent predictors of dislocation of HA. Such, several studies[10,15] highlighted the importance of simulated templating for preoperative evaluation and arthroplasty strategy.

Posterolateral approach, as the conventional and most commonly used surgery approach, has its advantage of surgical exposure and revision procedure. However, imbalance of hip muscle tendon leads to high tendency for posterior dislocation and early functional motivation. In the present study, the patients of tissue-sparing SuperPATH group benefited smaller incision length, lower transfusion rate and better early hip function recovery, as well as significantly decreasing risk of dislocation and reoperation postoperatively. Indeed, the statistically superior hip function recovery of SuperPATH group only existed in 1-week HHS, without in 1-month and 1-year scores. Ramadanov et al[12,30] reported the

similar conclusions, with less time to mobilization and better pain scores 1–3 months postoperatively in SuperPATH group. In our opinion, early hip function and mobilization recovery through this tissue-sparing approach could markedly contribute to decreasing the perioperative complications in these fragile patients. Considering the limited recovery capacity and rehabilitative cooperation of this senile and neuro-cognitive impairment population, the SuperPATH approach has certain advantages of reducing surgical trauma, promoting early weight-bearing and accelerating post-operative functional recovery.[14,31] Compared with the traditional group, the SuperPATH group had a smaller incision length and less transfusion rate, which might be attributed to less soft-tissue disruption and more complete capsular repair. Similar as Cevere et al[14] the groups did not differ in terms of perioperative hemoglobin loss, but lower transfusion was found in SP group, avoiding adverse reaction and economic burden for the geriatric patients.

As a relatively rare but serious complication, dislocation of hemiarthroplasty mainly occurs early after primary surgery, with rates reported varying between 0.8% and 6.1%.[23,32] Herein, the total dislocation incidence in high-risk population was 9.88%, which all occurred within two months of surgery. According to the previous study,[7] the dislocated HA patients tend to be much frailer with poorer bone and soft-tissue quality than THA. Closed reduction does not address the main factors that contribute to HA dislocation. Three cases (50%) turned out to be stable after close reduction, which is comparable to the prior studies whose re-dislocation rate ranged from 44% to 80%.[27,33] Further, once the hip is found to be unstable following an open reduction or several times of close reduction, revision arthroplasty should be performed. Regarding the complication, there was no significant difference between two groups. Furthermore, the incidence of reoperation was significantly lower in SP group ($OR = 0.198$, $P < 0.05$). Such, we considered that the avoidance of complications to be clinically relevant but statistically non-significant trend in SP group. Totally, the one-year mortality for all geriatric patients with high risk of dislocation was 18/81 (22.22%), with 7/39 (17.95%) in SP and 11/42 (26.19%) in PL group, respectively. Although the one-year mortality rate was lower in the SP group compared to the PL group, the difference was not statistically significant. This may be due to limited statistical power arising from the small sample size, and the possibility of a Type II error cannot be excluded. Notably, 1-year mortality rate was reported to be 44% in the dislocated HA group and 14% in the matched control group.[25] For those patients with unsuccessful closed reduction, revision THA with a constrained liner should be considered when possible. Dislocation is associated with increased mortalities, multiple admissions to the hospital, and possible revision surgeries. Indeed, there was no significant difference of the long-time hip functional motivation and post-operative mortality between two groups, as reported previously.[12,30] However, reducing the risk of dislocations certainly improves their quality of life during the little time they have left.

The limitations of our study should be noted. First, this was retrospective study. Second, this investigation included a relatively small number of sample size and procedure a short follow-up time. However, patients with high risk of dislocation are uncommon, and the results of the statistical analysis indicated reliable reproducibility. Third, patients could not be blinded for surgery approach. Thus, positive preconceptions may influence patients' pain and early-time rehabilitation. Further study expanding the sample size, average-risk elderly patients and follow-up time will better clarify the evidence-based clinical outcomes and complications of HA through SuperPATH and the other approaches.

In conclusion, the tissue-sparing SuperPATH approach presents the benefits of minimizing soft tissues injury, decreasing blood transfusion demand and early hip functional recovery following HA for femoral neck hip fracture in geriatric patients. When addressing elderly patients with high risk for dislocation, SuperPATH approach for bipolar HA might be considered to reduce dislocation and reoperation incidence than posterolateral approach.

Data Sharing Statement

All the data used and/or analyzed during this study are available upon reasonable request from the both corresponding authors.

Ethical Approval and Consent to Participate

This study was approved by the institutional review board of Guangdong Provincial People's Hospital (IRB: KY2024-363-01) and Ganzhou Hospital (IRB: SKJJ2024008H). All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained in writing from all the individual participants included in the study. This study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for Publication

Written informed consent was obtained from all patients for publication of this study and any accompanying images.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests for this work.

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