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Comparison of clinical outcomes between posterolateral approach and modified Hardinge approach in salvage total hip arthroplasty after medial buttress plate failure for femoral neck fractures

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Abstract. – OBJECTIVE: The purpose of this study was to investigate the clinical outcomes of salvage total hip arthroplasty (THA) after medial buttress plate surgery for femoral neck fractures *via* the modified Hardinge approach (MHA) and posterolateral approach (PLA) through a retrospective analysis.

PATIENTS AND METHODS: From October 2016 to October 2020, a total of 41 patients with failed femoral neck fractures treated with cannulated screws and medial buttress plates underwent unilateral salvage THA, and a retrospective study was conducted. According to the surgical approach, patients were divided into PLA group and MHA group. Clinical and radiological data were evaluated. The primary outcome indicators were the Pain Visual Analog Scale (VAS) and Hip Harris Score (HHS). Secondary outcome indicators include hemoglobin (HGB), hematocrit (HCT), creatine kinase (CK), creatine kinase-MB (CK-MB), etc. The occurrence of postoperative complications was also recorded.

RESULTS: There were no differences in demographic or clinical characteristics before surgery. There were no differences in postoperative HGB, HCT, CK-MB and radiological parameters. The surgical approach had no effect on the hospitalization period. The PLA group had earlier ambulation time, and the serum level of CK was also low. Analysis of the HHS and VAS showed that on postoperative day 3, the PLA group had superior scores. The incidence of complications did not significantly differ between groups.

CONCLUSIONS: The posterolateral approach for salvage THA provides better functional recovery with less muscle damage in the early postoperative period.

Key Words:
Femoral neck fractures, Medial buttress plate, Total hip arthroplasty, Posterolateral approach, Modified Hardinge approach.

Introduction

For young patients, femoral neck fractures are more common in high-energy injuries, and reduction and fixation are often used to preserve the hip joint[1]. There are many methods for the treatment of femoral neck fractures, such as cannulated screws and dynamic hip screws (DHS). However, the occurrence of complications such as nonunion, osteonecrosis of the femoral head (ONFH), and osteoarthritis are still a problem for traumatologists to prevent and solve[2,3]. In recent years, open reduction *via* direct anterior approach (DAA) using a hollow screw combined with a medial buttress plate has been applied to treat femoral neck fractures, especially for patients with Pauwels II-III, to improve fracture healing and reduce the incidence of ONFH (Figure 1). The surgical concept is anatomical reduction, preservation of the blood supply to the femoral head, and increasing the medial support of the femoral talar to avoid coxa vara[4,5]. With the popularization of this surgical technique and the extension of follow-up time, complications of the medial buttress plate are also increasing gradually. For patients with hip function loss, salvage total hip arthroplasty (THA) is needed to relieve pain and restore hip function[6]. Primary THA surgical approaches include the anterolateral[7], lateral[8] and posterolateral[9], each of which has its own advantages and disadvantages. The presence of a hollow screw and medial buttress plate may lead to excessive sclerosis of proximal bone or deformation of the medullary cavity. The choice of approach for salvage THA and the clinical efficacy of these patients have not yet been reported.

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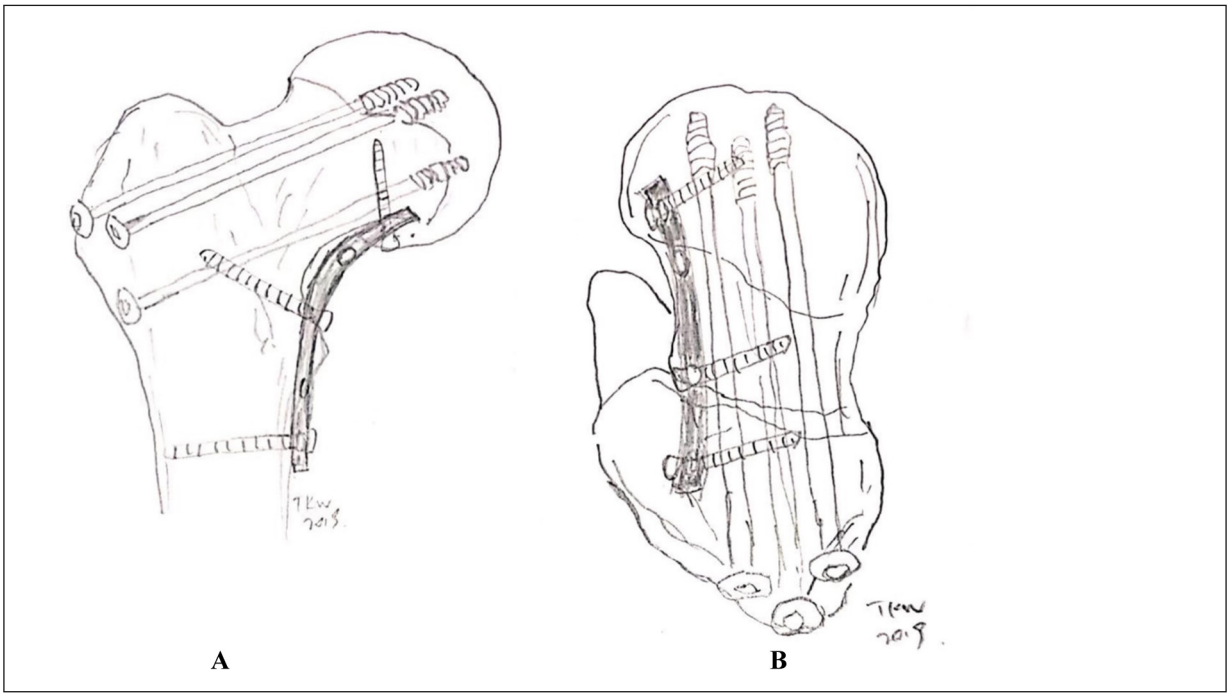

Figure 1. Treatment of femoral neck fracture with medial buttress plate combined with hollow screws through DAA approach, front (**A**), axial (**B**).

The purpose of this study was to investigate the clinical outcomes of salvage THA after medial buttress plate surgery for femoral neck fractures *via* the modified Hardinge approach (MHA) and posterolateral approach (PLA) through retrospective analysis. The aim of this study was to compare the differences between PLA and MHA in terms of postoperative functional recovery, postoperative serum markers of muscle injury, positioning of the joint prosthesis, and postoperative complications.

Patients and Methods

The study was approved by the Ethics Committee of our Hospital and all patients provided written informed consent. From October 2016 to October 2020, we performed unilateral salvage THA in 41 patients with failed femoral neck fractures treated with cannulated screws and medial buttress plates, and retrospectively analyzed the clinical results of this group of patients. Inclusion criteria are as follows: femoral neck fractures internal fixation method is cannulated screws combined with medial buttress plate, osteoarthritis of the hip, ONFH, nonunion, fixation failure. Exclusion criteria are as follows: neurological disorders, other internal fixation methods for femoral neck fractures, other hip arthrotomies except medial buttress plate, an inability to tolerate general anesthesia, and an unwillingness to participate in the study.

The following patient characteristics were recorded on admission: gender, age, body mass index (BMI), diagnosis, American Society of Anesthesiologists functional status (ASA), surgery side, hemoglobin (HGB), hematocrit (HCT), creatine kinase (CK), creatine kinase-MB (CK-MB), Visual Analog Scale (VAS), and Hip Harris Score (HHS). The preoperative general data of the patients in both groups are presented in Table I, and the differences between the groups were not statistically significant.

Perioperative Management and Surgical Procedures

Routine laboratory tests such as routine blood tests, biochemistry, erythrocyte sedimentation rate and C-reactive protein were performed on admission to rule out infection. Preoperative deep vein thrombosis was ruled out by ultrasound. Cefuroxime was used as a prophylactic antibiotic and one case was changed to clindamycin due to cephalosporin allergy.

Patients in this study had the same hip prosthesis and ceramic interface with two screws inserted in the acetabular side. Surgeries were performed by an experienced hip arthroplasty team.

Table I. Demographic and clinical characteristics of patients.

	MHA group (n=21)	PLA group (n=20)	*p*-value
Age (years)	41.19±8.52	41.00±10.00	0.948[a]
BMI (kg/m^2)	25.56±3.55	25.67±1.74	0.893[a]
Sex (M/F)	4/17	9/11	0.074[b]
Diagnosis			0.889[b]
ONFH	10	8	
Osteoarthritis	6	5	
Nonunion	2	3	
Fixation failure	3	4	
Side (L/R)	9/12	14/6	0.080[b]
ASA status (I/II/III)	4/15/2	6/13/1	0.653[b]
CK (U/L)	67.38±19.29	70.55±20.51	0.613[a]
CK-MB (U/L)	9.52±2.93	9.60±3.32	0.938[a]
HGB (g/l)	120.52±11.13	124.75±11.65	0.242[a]
HCT (%)	36.10±4.42	36.76±3.68	0.610[a]
HHS	51.64±4.97	49.81±4.06	0.206[a]
VAS	6.7±1.4	6.9±1.4	0.677[a]

Values are mean±SD. SD, standard deviation. [a]Student *t*-test. [b]Pearson's Chi-squared test. Modified Hardinge approach (MHA), posterolateral approach (PLA), American Society of Anesthesiologists functional status (ASA), hemoglobin (HGB), hematocrit (HCT), creatine kinase (CK), creatine kinase-MB (CK-MB), Pain Visual Analog Scale (VAS), Hip Harris Score (HHS).

Modified Hardinge Approach

The skin, subcutaneous tissue, and fascia are incised layer by layer. The proximal femoral hollow screw was exposed and removed. After the incision of the iliotibial tract, gluteus maximus muscle was bluntly separated, and the gluteus medius was exposed and pulled by blunt separation from the anterior 1/3 of the gluteus medius, and the gluteus minimus was exposed to cut the stop point of the trochanter, the hip joint capsule, surrounding ligamentous tissues were incised and the proliferative or hypertrophic parts were excised, and the neck of the femoral head was exposed. The hip joint was externally rotated and abducted, the medial support plate and screws were exposed, the internal fixation was removed and then a femoral neck osteotomy for THA was performed (Figure 2).

Posterolateral Approach

The skin, subcutaneous tissue, and fascia are incised layer by layer. The proximal femoral hollow screw was exposed and removed. The gluteus medius was retracted and protected, and the external rotating muscle was cut off at the stop point; the posterior capsule of the joint was fully exposed and resected for posterior flexion, adduction, and internal rotation. The medial buttress plate and screw were removed for femoral neck osteotomy and THA.

Perioperative management was the same for all patients: a fast-track rehabilitation philosophy with multimodal analgesia and antibiotic application, anticoagulation with rivaroxaban. Isometric contraction exercises of the operated limbs were performed on the first postoperative day, with partial weight-bearing activity from 3-7 days to 6 weeks after surgery and full weight-bearing thereafter.

Primary Outcomes

Postoperative pain was measured by an independent observer who did not participate in the surgery using VAS at 3 days, 1 month, and 3 months after the surgery. The range was from 0 to 10, where 0 indicated no pain, and 10 indicated the most severe pain. The HHS was assessed at 3 days, 1 month, and 3 months after surgery.

Secondary Outcomes

The operative time, intraoperative bleeding, postoperative complications, ambulation time and hospitalization period were recorded. HGB, HCT, CK-MB and CK were recorded on postoperative day 1, day 3 and day 6. Pelvis radiographs and axial hip radiographs were taken for observation. The abduction and anteversion angles of the acetabular component and the position of the stem were compared. Heterotopic ossification was graded according to Brooker et al[10]. The radiological parameters were independently determined by two observers.

Postoperative Complications

Complications such as periprosthetic fracture, nerve injury, prosthesis dislocation, heterotopic

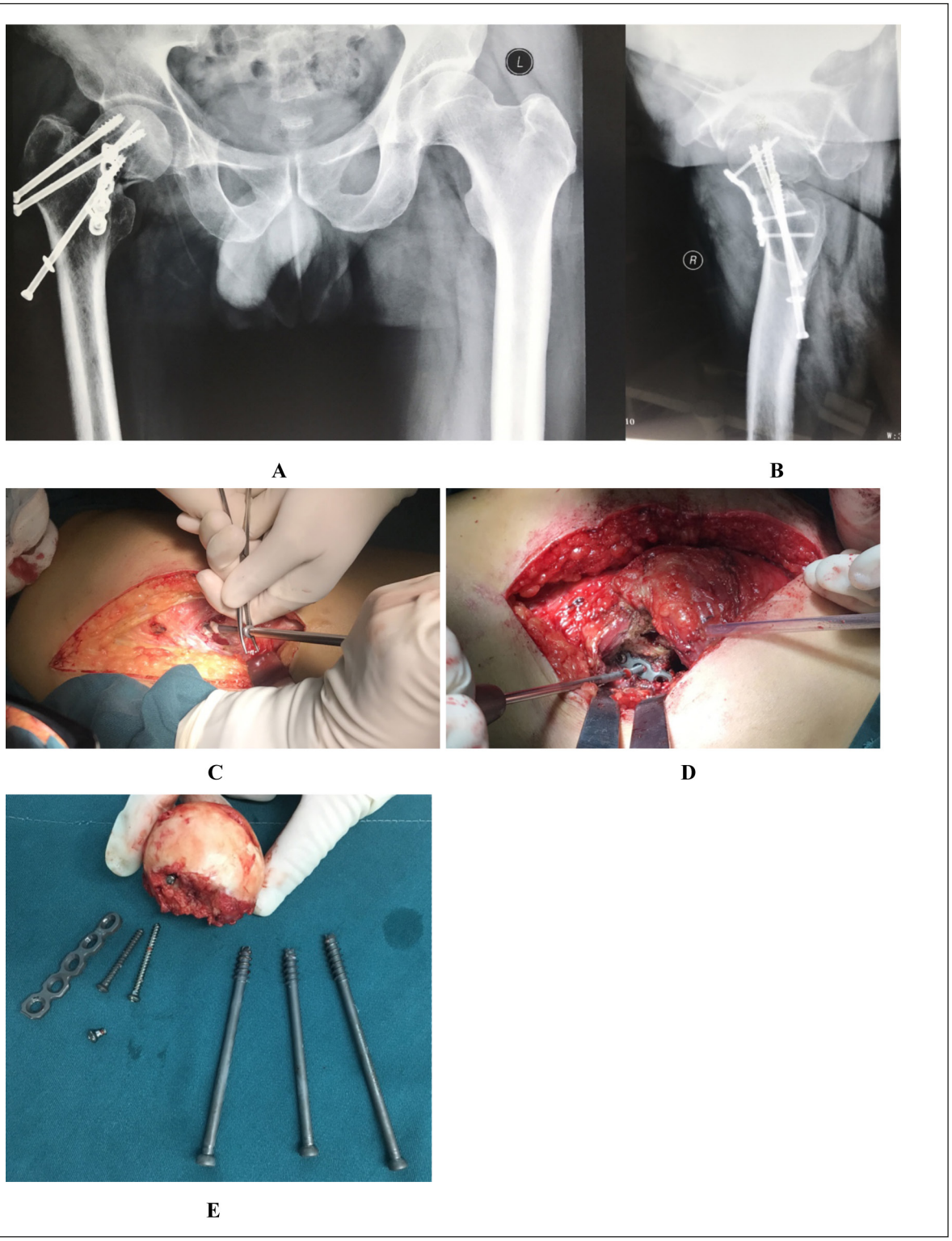

Figure 2. Radiographs of a 50-year-old man showing medial buttress plate combined with hollow screws for femoral neck fracture with nonunion and hollow screws retraction (**A-B**). The modified Hardinge approach removes hollow screws at the greater trochanter (**C**). After flexion and external rotation, the medial buttress plate (**D**) is removed through the front. Femoral head and internal fixation after removal (**E**). Axial radiographs of the lower pelvis and hip joint showing salvage THA for failed internal fixation (**F-G**). Prosthesis position at last follow-up (**H-I**).

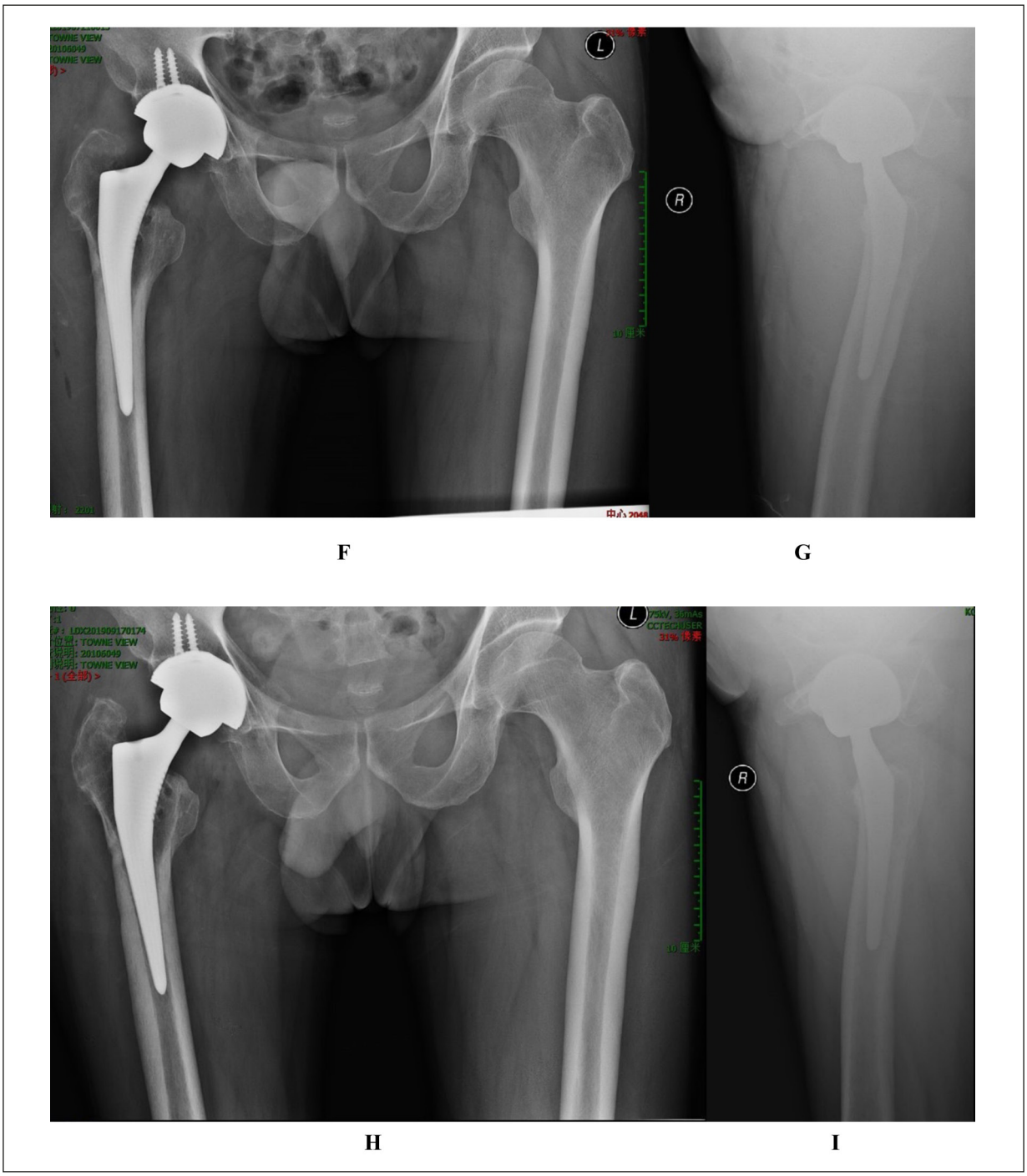

Figure 2*(Continued)*. Radiographs of a 50-year-old man showing medial buttress plate combined with hollow screws for femoral neck fracture with nonunion and hollow screws retraction (**A-B**). The modified Hardinge approach removes hollow screws at the greater trochanter (**C**). After flexion and external rotation, the medial buttress plate (**D**) is removed through the front. Femoral head and internal fixation after removal (**E**). Axial radiographs of the lower pelvis and hip joint showing salvage THA for failed internal fixation (**F-G**). Prosthesis position at last follow-up (**H-I**).

ossification, osteolysis, postoperative infection and venous thromboembolism (VTE) were recorded.

Statistical Analysis

Statistical analysis was performed by two investigators using SPSS (version 19.0, IBM Corp.,

Armonk, NY, USA). The measurement data were expressed as mean ± standard deviation using *t*-test; the count data were expressed as the number of cases using the Chi-square test. Spearman's correlation analysis determined the correlation between VAS and CK, with $p<0.05$ considered significant.

Results

Primary Outcomes

On postoperative day 3, patients in the PLA group had significantly better VAS and HHS. There was no difference between the groups in VAS and HHS at other time points (Table II).

Secondary Outcomes

There were no differences in operative time, intraoperative bleeding, or hospitalization period between the two groups. Serum CK in the PLA and MHA groups was elevated on postoperative day 1, showed a decrease on postoperative day 3, and gradually normalized by postoperative day 6. CK levels were significantly higher in the MHA group than in the PLA group on postoperative day 3. The PLA group had an earlier ambulation time. There was no significant difference in HGB, HCT at any time point (Table II). The abduction and anteversion angles of the acetabular component and the position of the stem did not differ between the two groups (Table III). Spearman's correlation analysis showed a correlation between VAS and CK ($p=0.002$).

Postoperative Complications

There was no dislocation, loosening or sinking of the prosthesis during the follow-up period. One case of periacetabular heterotopic ossification occurred in the MHA group, which was Brooker grade I. There was no special treatment. No complications such as infection, VTE, or osteolysis occurred in either group.

Discussion

Due to the special biological and biomechanical characteristics of the femoral neck, the risk of bone nonunion and femoral head necrosis after femoral neck fracture remains high. In young patients with a strong desire for hip preservation with femoral neck fractures, DAA incisional hollow screws with medial buttress plate internal fixation for treatment have been performed since 2016. The early surgical results of the medial buttress plate are encouraging, when patients develop postoperative complications such as ONFH, salvage THA is required to relieve pain and restore hip function. That is important for habitual physical activity and especially in younger patients in order to return as early as possible to their working place. In previous salvage THA of failed internal fixation for femoral neck fractures, hardware removal can be readily performed because fractures are fixed with pins or screws. When a medial buttress plate is present, removal of the internal fixation is relatively difficult, and the possible damage to the periarticular soft tissues varies between surgical approaches.

The lateral or posterolateral approach is generally chosen for salvage THA after the failure of hollow screw internal fixation, which allows direct removal of the internal fixation for THA and effectively shortens operation time, and reduces intraoperative bleeding[11,12]. When the additional medial buttress plate is present, the choice of which approach to perform the procedure is challenging. The length of operation and the amount of intraoperative bleeding are related to the complexity of the procedure in addition to surgical proficiency. Winemaker et al[13] reported an operative time of 95±32.8 min for salvage THA after failed internal fixation of femoral neck fractures. Yang et al[14] reported an operative time of 99.77±37.97 min for salvage THA after failed treatment of femoral neck fractures with 49 cannulated screws, 6 DHS, 3 kerf pins and other internal fixation. The operative time of 40 patients in this study was 110±5.36 min, including 109.10±6.08 min in the MHA group and 110.90±4.52 min in the PLA group. All were longer than the primary THA operative time of 36±15 min[15]. We found that MHA to remove the medial buttress plate required extreme flexion and external rotation of the hip to effectively expose the internal fixation, and this approach took more time to fully release the anterior soft tissue to expose the internal fixation in patients with arthritis and severe soft tissue scar adhesions after initial medial buttress plate surgery. When PLA is chosen, the damage to soft tissues anterior to the hip joint is reduced, the joint capsule is fully released, and internal rotation of the flexed hip can effectively expose internal fixation. Not all internal fixations can be clearly visualized and simply removed. During surgery for salvage THA complicated by ONFH following failed medial buttress plate, it is often found that the threaded portion of the head end of

Table II. Comparison of outcomes between two groups.

	MHA group (n=21)	PLA group (n=20)	*p*-value[a]
Intraoperative bleeding (ml)	284.76±47.50	272.00±52.17	0.417
Operative time (min)	108.67±6.25	110.90±4.52	0.199
Hospitalization period (day)	10.48±0.93	10.35±0.93	0.667
Ambulation time (day)	3.90±0.77	2.65±0.49	0.000
HHS			
Postoperative			
3 d	60.82±4.18	64.26±6.13	0.041
1 mo	73.41±1.19	74.34±2.26	0.113
3 mo	85.19±6.75	83.55±8.59	0.500
VAS			
Postoperative			
3 d	3.8±0.8	2.8±0.6	0.000
1 mo	1.9±0.6	2.0±0.5	0.801
3 mo	1.8±0.5	1.4±0.8	0.106
HGB (g/l)			
Postoperative			
1 d	107.52±4.42	109.05±8.48	0.543
3 d	96.33±8.53	96.75±7.91	0.872
6 d	92.81±10.00	94.05±9.07	0.680
HCT (%)			
Postoperative			
1 d	34.07±0.90	33.65±2.83	0.535
3 d	29.20±0.84	29.90±1.59	0.093
6 d	28.41±1.36	28.14±2.82	0.692
CK (U/L)			
Postoperative			
1 d	466.76±49.91	447.85±62.45	0.290
3 d	379.24±70.71	324.30±42.20	0.005
6 d	57.38±19.29	63.80±12.99	0.218
CK-MB (U/L)			
Postoperative			
1 d	16.76±2.70	15.95±1.90	0.275
3 d	11.00±7.15	12.60±5.31	0.423
6 d	11.33±4.26	10.40±5.49	0.545

Values are mean±SD. SD, standard deviation. [a]Student *t*-test. Modified Hardinge approach (MHA), posterolateral approach (PLA), American Society of Anesthesiologists functional status (ASA), hemoglobin (HGB), hematocrit (HCT), creatine kinase (CK), creatine kinase-MB (CK-MB), Pain Visual Analog Scale (VAS), Hip Harris Score (HHS).

Table III. Radiographic outcomes of patients.

	MHA group (n=21)	PLA group (n=20)	*p*-value
Anteversion (°)	21.33±2.52	21.25±4.23	0.939[a]
Abduction (°)	40.52±3.70	39.80±4.47	0.574[a]
The position of the stem (n, %)			0.614[b]
Neutral	19 (90.4%)	19(95.0%)	
Varus	1 (4.8%)	1 (5.0%)	
Valgus	1 (4.8%)	0 (0.0%)	

Values are n (%) or mean±SD. SD, standard deviation. [a]Student *t*-test. [b]Pearson's Chi-squared test. Modified Hardinge approach (MHA), posterolateral approach (PLA).

the hollow screw has completely penetrated the femoral head. This causes the screw to rotate in place at a greater trochanter when it is screwed out and cannot be removed. Therefore, the only way to reveal the threaded portion of the screw head is to perform a femoral neck osteotomy and bite off the femoral head, then sew off the end of the screw and remove it from the head end in reverse. When the medial plate breaks, a broken nail or screw wears out, then the removal of the internal fixation becomes time-consuming and laborious. Intraoperative bleeding in this study was 272±52

ml in the PLA group and 286±48 ml in the MHA group. This is close to Yang et al[14] who reported intraoperative bleeding of 253.64±171.95 ml in salvage THA after failed hollow nail internal fixation. Moon et al[16] reported 59 cases of salvage THA bleeding of 535.2±121.5 ml. All were more than primary THA bleeding of 165±70 ml[15]. As for longer operative time and more blood loss for patients with failed internal fixation, potentially reasonable explanations could be scar healing and deformity with previous surgery, probably resulting in more surgical injuries. Disuse osteopenia and residual bony defect with the removal of the original hardware in the proximal femur, all pose technical challenges to successful reconstruction. Furthermore, because of the absence of sclerotic subchondral bone typically present in elective osteoarthritic THA instead of these salvage THA, press-fit of biotype acetabular components may be difficult1[7,18].

Previous studies[13] have reported no significant difference in mean HHS when comparing initial THA to salvage THA in osteoarthritis. Even when internal fixation of femoral neck fractures fails, salvage THA produces good clinical outcomes comparable to primary THA. This may be because patients who develop osteonecrosis or osteoarthritis after femoral neck fracture healing may have a period of reasonable function and mobility before salvage THA and, therefore, a better functional outcome after salvage THA than preconception[19]. Moon et al[16], in their study, included 59 cases of salvage THA who had a preoperative HHS of 42.1±4.1, which was elevated to 96.7±9.1 postoperative. Tetsunaga et al[20] previously reported an improvement in HHS to 90.5 at the last follow-up in 18 salvage THA of femoral neck fractures. Winemaker et al13 found a mean HHS of 79.3±11.7 after salvage THA with an excellent postoperative hip functional recovery and significant clinical outcomes. The preoperative HHS (49.81±4.06, PLA; 51.64±4.97, MHA) gradually increased to (83.55±8.59, PLA; 85.19±6.75, MHA) at 3 months postoperatively and the preoperative VAS (6.9±1.4, PLA; 6.7±1.4, MHA) decreased to (1.4±0.8, PLA; 1.8±0.5, MHA) in this study with good clinical outcomes. However, we found that the PLA group had better HHS and VAS on postoperative day 3, along with earlier ambulation time. Although pre-operative CK levels were similar in both groups, CK levels were significantly higher in the MHA group than in the PLA group on postoperative day 3. CK is present in skeletal muscle in high concentrations and is released into the blood when the myocyte membrane is damaged. Therefore, CK is a preferred indicator for assessing muscle damage and reflects the extent of soft tissue damage during surgery. Similar conclusions can be drawn from the results of the relevant literature, where muscle damage is greater in patients with higher CK levels in THA surgery[21,22]. VAS in the MHA and PLA groups were positively correlated with postoperative serum CK by Spearman's correlation analysis, so it can be assumed that muscle damage influenced the VAS assessment. Most patients in the MHA group complained of pain at the greater trochanter and anterior to the hip joint in a short postoperative period. This may be because direct trauma through MHA causes pain at the greater trochanter, and pain in the anterior aspect of the hip may be caused by the release of scar tissue. As a result, muscle damage was more severe and postoperative serum CK levels were high. Patient sensitivity and functional activity to exercise are strongly influenced by clinical pain and hypersensitivity to painful stimuli around the wound. The incision site causes damage to cutaneous and tissue pain receptors with subsequent overstimulation of the spinal cord. Any stimulation or action, even if it may not be painful, is considered potentially harmful to the central nervous system. Therefore, patients in the MHA group may be reluctant to attempt floor activities or functional hip exercises to a large extent out of fear. A previous report[23] has also suggested that greater trochanteric pain affects patient satisfaction and functional outcomes after THA. Patients operated through MHA reported more pain and less satisfaction compared with PLA. However, there was no difference between MHA and PLA groups in terms of the hospitalization period. There was no significant difference in HHS and VAS between the two groups at 3 months postoperatively. So, whether MHA or PLA, satisfactory clinical results can be achieved by the end.

There are many more complications associated with salvage THA after failed femoral neck fractures than after primary THA, including dislocation, infection, and periprosthetic fracture. It also increases the risk of early complication, inferior hip function and higher revision rate[24]. Salvage THA after failed femoral neck fracture treatment is associated with a higher risk for deep infection than primary THA, occurring in approximately 6% of cases[25]. Prolonged operating time is associated with an elevated likelihood of

relative risk of venous thromboembolism and is also associated with an increased incidence of infection[26,27]. A total of 98 patients were included in Mahmoud et al[28] assessment. The complications of salvage THA included 4 dislocations, 4 infections, 2 periprosthetic fractures, 2 cases of prosthetic loosening and a single case of post-operative myocardial infarction. Moon et al's[16] study reported 59 cases of salvage THA after failed femoral neck fracture in 4 cases of postoperative dislocation and 0 cases of infection. A previous study by Weiss et al[29] suggested that the majority of patients undergoing salvage THA after failure of hollow nail internal fixation were elderly patients with a higher incidence of intraoperative periprosthetic fractures due to their own osteoporosis, or concomitant bone loss. Patients with femoral neck fractures treated using the medial buttress plate technique are mostly young and active, and no intraoperative or postoperative periprosthetic fractures have been observed. We have not observed other complications up to the time of the last follow-up, and only 1 patient in the MHA group developed periacetabular heterotopic ossification postoperatively. This is similar to the findings of Tetsunaga et al[20], whose 18 cases of THA after failed internal fixation of proximal femoral fractures had a complication rate of 0.

Of course, our study also has limitations. 1. The appearance of the medial buttress plate technique is still short, and the treatment concept of femoral neck fractures in young patients is different, which also caused the limited number of patients included in this study. The follow-up period is too short and limited to a single-center study. 2. In clinical practice, the medial buttress plate was not removed through DAA because most patients required a single surgical incision to complete salvage THA and avoid additional incisions. The contrast in the clinical effectiveness of DAA combined with PLA or MHA is missing. 3. This study was a retrospective study at a single center. The next work will also require a multi-center consortium to increase the sample size, leading to a more detailed analysis of the factors underlying salvage THA results.

Conclusions

The results of this study indicate that salvage THA after hollow screw of femoral neck fracture combined with failure of medial buttress plate can significantly improve HHS and reduce VAS with good clinical results. Both the MHA and the PLA can be used for salvage THA after the failure of the medial buttress plate for femoral neck fractures without an increased risk of complications. The PLA had better functional recovery with less muscle damage in the early postoperative period.

Conflict of Interest

No conflict of interest exists in the submission of this manuscript.

Funding

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Ethics Approval

This study was approved by the Medical Ethics Committee of the Luoyang Orthopedic-Traumatological Hospital of Henan Province (Henan Provincial Orthopedic Hospital, approval No. 20200031).

Informed Consent

Informed consent was obtained from all participants.

Authors' Contributions

Dawei Liang contributed significantly to the analysis and wrote the manuscript; Jia Pei performed the data analyses; Xiaohui Zhang, Kewei Tian helped perform the analysis with constructive discussions. All authors read and approved the final manuscript.

Availability of Data and Materials

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

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