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Clinical analysis of Ganz approach in the treatment of Pipkin type IV fracture: a retrospective review

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Abstract

Purpose This study aimed to evaluate the early clinical outcomes of the Ganz approach in treating Pipkin IV fractures.

Methods From January 2016 to January 2021, 22 patients with Pipkin IV fracture were treated in our department with Ganz approach. The operation time, intraoperative blood loss, fracture healing time, the incidence of postoperative complications such as heterotopic ossification of hip joint and avascular necrosis of femoral head were recorded. Radiological assessment of fracture reduction was achieved using Matta's evaluation criteria. The functional recovery of the hip joint was assessed using the Harris Hip Score at one year and before the current study, as well as the modified Merle d'Aubigné and Postel score during the final evaluation.

Results 21 patients were available for follow up. The average intraoperative blood loss was 145.5 ± 39.3 ml and the average operation time was 150.4 ± 40.6 min. The average follow-up time was 39.2 ± 11.2 months. X-ray confirmed bony healing of the femoral head, acetabular fractures, and greater trochanter osteotomy, with an average healing time of 7.22 ± 3 months. The difference between the Harris hip score of hip joint at one year and at the last follow-up was not statistically significant ($p = 0.06$). At final follow up with the modified Merle D'Aubigne Postel score, nine had excellent functional outcome; ten presented very good to good result while two patients had average (one) to poor (one) result. Two (9.5%) patient developed osteonecrosis (avascular necrosis) of the femoral head.

Conclusion The Ganz approach effectively preserves the blood supply to the femoral head, moreover, it also fully expose the operative fields such as hip joint and femoral head, achieving satisfactory clinical outcomes, making it a valuable option for clinical application.

Keywords Femoral head fracture, Acetabular fracture, Pipkin IV, Internal fixation, Greater trochanter osteotomy

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Introduction

A Type IV fracture, characterized by a femoral head fracture-dislocation combined with a posterior wall acetabular fracture, represents a complex hip joint injury typically resulting from high-energy trauma [1]. This fracture primarily results from significant force transmitted to the femoral head via the femoral shaft; the femoral head has a large contact area with the posterior wall of the acetabulum, as the consequence when the femoral head violently hits the acetabulum, it results in fractures of the femoral head and acetabulum, of which Pikin IV fracture is the most common type and described as fracture of the anterior inferior femoral head and the posterior wall of the acetabulum [2–5].

Studies have shown that about 5–15% of posterior hip dislocation is associated with fracture of the femoral head [3, 6]. The treatment of patients with femoral head fracture is clinically difficult, the prognosis is often poor [7–10]; these fractures are prone to complications such as avascular necrosis of the femoral head, traumatic arthritis, heterotopic ossification [11, 12]. Clinical experience has shown that achieving satisfactory reduction is challenging with conservative management, therefore surgical treatment is considered as the first choice.

The purpose of the operation in Pipkin IV fracture is to restore the articular surface and firmly fix the fracture, which is helpful for patients to carry out the functional activity of the affected limb earlier during the rehabilitation stage [13]; for young and middle-aged patients presenting acetabular fractures with typical displacement and without obvious medical comorbidities, surgical internal fixation is still advocated.

Conventional surgical approaches are difficult to meet the anterior and posterior exposure of the hip joint, so the choice of surgical approach for Pipkin IV fracture is still controversial [14, 15]. The key to clinical treatment of Pipkin IV fracture is to choose a surgical approach that can not only fully expose the operative field but also protect the blood supply of the femoral head to the maximum extent. The recovery of articular surface flatness and the protection of blood supply of femoral head during operation can effectively reduce the incidence of complications such as osteonecrosis of femoral head and traumatic hip arthritis [12].

The Ganz approach provides comprehensive exposure of the hip joint operative field [16]. This approach not only has the advantage of assessing the operative field without damaging the blood supply of the femoral head, but also can take into account the reduction and fixation of femoral head and acetabulum fracture. This study aimed to evaluate the very early clinical outcomes of 21 consecutive patients with Pipkin IV fractures treated using the Ganz approach.

Materials and methods

In this retrospective single center study realized from June 2018 to June 2023, a total of 22 patients with femoral head fracture were included. This study was approved by the Institutional Review Board and the Ethics Committee of the first affiliated hospital of Nanchang University (Date-number: 2023 – 220). Because this study was conducted in accordance with the declaration of Helsinki, and given the retrospective nature of the study without the privacy of patients being breached, the informed consent was waived from the patients; patients demographic and clinical data were therefore retrieved from the hospital information system and represented anonymously on a blinded excel file. All participants provided their consent prior to undergoing the surgical procedure. The cohort consisted of 18 male and 4 female patients, aged between 27 and 51 years, with a mean age of 37.5 years.

The inclusion criteria included: (1) Pipkin IV femoral head fracture with fracture displacement of > 2 mm; (2) injury time ≤ 3 weeks.

Exclusion criteria: (1) open femoral head fracture or injury time > 3 weeks; (2) complicated with other concomitant serious injury or other surgical contraindications; (3) a comminuted fracture of the femoral head, where anatomical reduction and stable fixation cannot be achieved; (4) postoperative follow-up ≤ 12 months or drop out. Patients with hip dislocation were treated with femoral supracondylar traction or skin traction, and surgical treatment was performed 5 to 13 days after injury (mean 8 ± 4 days). The clinical outcomes such as: incidence of avascular necrosis, posttraumatic osteoarthritis, heterotopic ossification and the functional outcome of the hip (Range of Motion) were analyzed and compared within patients at one year and after the completion of follow-up.

Surgical procedure

Under general anesthesia, the patient was positioned in the contralateral recumbent position. The surgical field was prepared with antiseptic solution, and sterile drapes were applied. The approach was "the Kocher-Langenbeck approach": A 12 to 14 cm incision was made extending from the posterior superior iliac spine to the greater trochanter and further to the lateral thigh. The incision was carried through the skin, subcutaneous tissue, and fascia.

Using a pendulum saw, osteotomy of the greater trochanter was performed through the gluteus medius and lateral femoral muscles. The detached greater trochanter, along with the attached gluteus medius, was retracted anteriorly to expose the hip joint. The gluteus minimus and joint capsule were fully visualized, and the piriformis tendon was isolated.

Special care was taken to preserve the deep branch of the medial circumflex femoral artery and the sciatic nerve. A Z-shaped incision was made on the joint capsule, followed by flexion and external rotation of the femur to dislocate the hip joint and achieve full exposure of the femoral head (Fig. 1a). Once satisfactory reduction was obtained, the femoral head was temporarily stabilized using either 2 mm Kirschner wires (K-wires) or pointed reduction forceps (Fig. 1b).

The fracture fragments were then secured using 2–3 non-absorbable screws (Herbert screws) or 4 mm/2.7 mm cannulated screws. The posterior wall fracture was fully exposed, and all debris and hematoma within the joint cavity were removed. During the procedure, a drilling test was performed to assess the vascularization of the femoral head (Fig. 1c).

Under direct visualization, the posterior wall fracture of the acetabulum was anatomically reduced utilizing a pelvic reduction rod and temporarily stabilized with Kirschner wires (K-wires). Definitive fixation was achieved using lag screws in combination with a 3.5 mm reconstruction plate. The accuracy of the fracture reduction was confirmed intraoperatively using fluoroscopic imaging (Fig. 1d).

For posterior labral tears, management involved debridement of severely damaged edges or repair with anchor sutures if the torn portion remained attached to the avulsed osseous fragment. Vascular integrity of the femoral head was systematically evaluated in all cases using an intraoperative drilling test following fixation of the femoral head fracture.

The procedure was completed by performing flexion and internal rotation of the femur to achieve congruent reduction of the hip joint. Fixation of the greater trochanter osteotomy was performed using either a 7.3 mm cannulated screw or a K-wire with a tension band technique after the joint capsule was securely sutured. Figure 1 provides a detailed illustration of the surgical steps.

Perioperative management

All patients underwent emergency closed reduction of the hip dislocation within 6 h of injury. Postoperatively, second-generation cephalosporins were routinely administered to prevent surgical site infections (SSI). Rivaroxaban was prescribed for 35 days to prevent deep vein thrombosis (DVT) of the lower extremities, and indomethacin was administered for 4 weeks to reduce the risk of heterotopic ossification.

Passive range-of-motion exercises for the hip joint were initiated 6 weeks postoperatively. Partial weight-bearing was permitted after 8 weeks, progressing to full weight-bearing exercises at 12 weeks, based on fracture healing as assessed through serial radiographs. Follow-up radiographic imaging was performed at 1 day, 1 month,

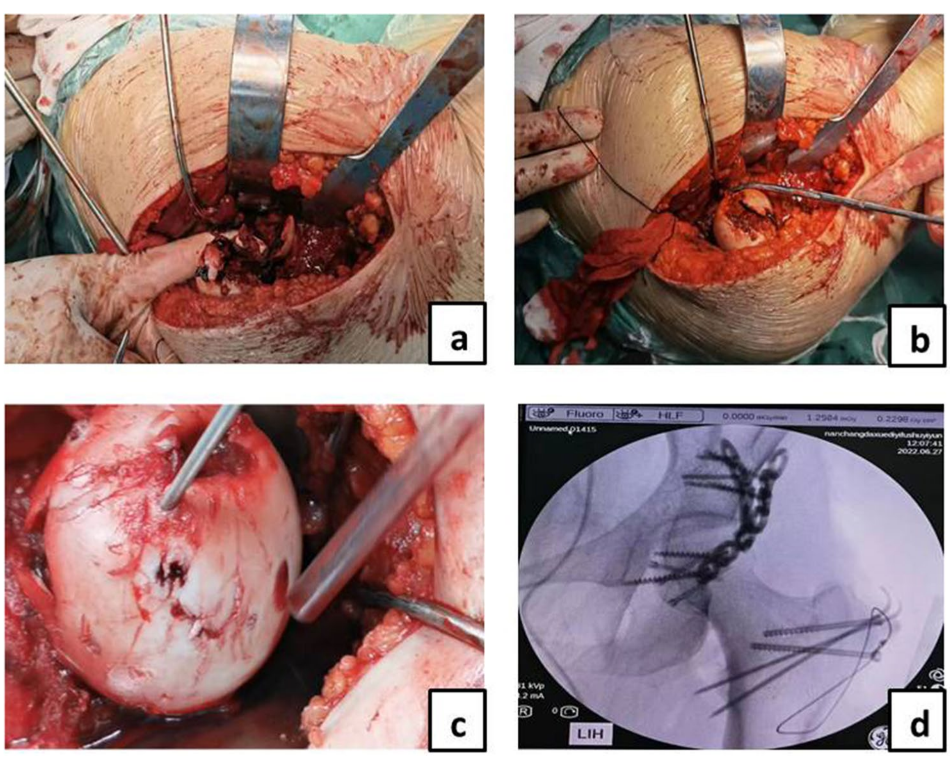

Fig. 1 Intraoperative images: (**a**) shows the intraoperative fracture exposure after flexion-external rotation of the femur, dislocation of the hip joint and full exposure of the femoral head; (**b**) demonstrates intraoperative temporary fixation with pointed reduction forceps; (**c**) Intraoperative drilling test showing bleeding of the fractured femoral head; (**d**) intraoperative fluoroscopic image demonstrating good fracture reduction

3 months, 6 months, and 1 year postoperatively. Wound healing and clinical outcomes were evaluated in accordance with established follow-up protocols and clinical assessment criteria.

Preoperative radiological evaluation of fractures was performed using plain digital radiography (DR) and computed tomography (CT) scans (Fig. 2a, b, and c). Postoperative assessment of fracture reduction accuracy was conducted based on Matta's criteria. Postoperative fracture reduction and bone healing of the femoral head, acetabulum, and greater trochanter osteotomy were monitored via X-ray at 1 day (Fig. 2d), 1 month, 3 months (Fig. 2e), 6 months, and 1 year (Fig. 2f) after surgery.

Operative parameters recorded included surgical duration, intraoperative blood loss, fracture healing time, and the incidence of complications such as infection, heterotopic ossification of the hip joint, and avascular necrosis of the femoral head.

Postoperative hip joint function was assessed using the Harris Hip Score (HHS) [17], evaluated preoperatively and 1 year postoperatively. The HHS measures pain, functional capacity, and range of motion, with a maximum score of 100. Outcomes were categorized as excellent (≥ 90), good (80–89), fair (70–79), and poor (< 70). Functional outcomes were further evaluated using the modified Merle D'Aubigne-Postel score, which assesses pain, mobility, and walking ability. Each component was rated on a scale from 0 to 6, with a total maximum score of 18 for a normal hip. Outcomes were classified as excellent (18 points), very good (17 points), good (15–16 points), fair (13–14 points), poor (9–12 points), and bad (< 9 points). A positive correlation was observed between higher scores and improved hip joint function (Fig. 2g and h).

Statistical analysis

Statistical analysis in this study was conducted using SPSS version 26.0 software. Continuous variables were expressed as mean ± standard deviation (SD). Differences in clinical outcomes between the two time points (1 year postoperatively and at the final follow-up) were assessed using an independent samples t-test. A p-value of < 0.05 was considered statistically significant.

Results

All 22 patients underwent successful surgery; however, 21 patients completed the follow-up evaluation, while one patient was lost to follow-up and excluded from the study. The fracture reduction was satisfactory on radiographic images. The average intraoperative blood loss was 145.5 ± 39.3 ml and the average operation time was 150.4 ± 40.6 min.

The average follow-up time was 39.2 ± 11.2 months, with a range of 19 to 58 months. X-ray confirmed bony healing of the femoral head, acetabular fractures, and greater trochanter osteotomy, with an average healing time of 7.22 ± 3 months. There were no postoperative complications such as nonunion, heterotopic ossification; however two (9.5%) cases developed avascular necrosis of the femoral head.

The Harris Hip Score at one-year post-operation and at the final follow-up was 83.1 ± 5.8 and 89.7 ± 9.6, respectively, with no statistically significant difference ($p = 0.06$). Following final evaluation with the modified Merle D'Aubigne Postel score, nine had excellent functional outcome; ten presented very good to good result while two patients had average (one) to poor (one) result. The basic clinical data as well as the follow-up findings are summarized and reported in Table 1.

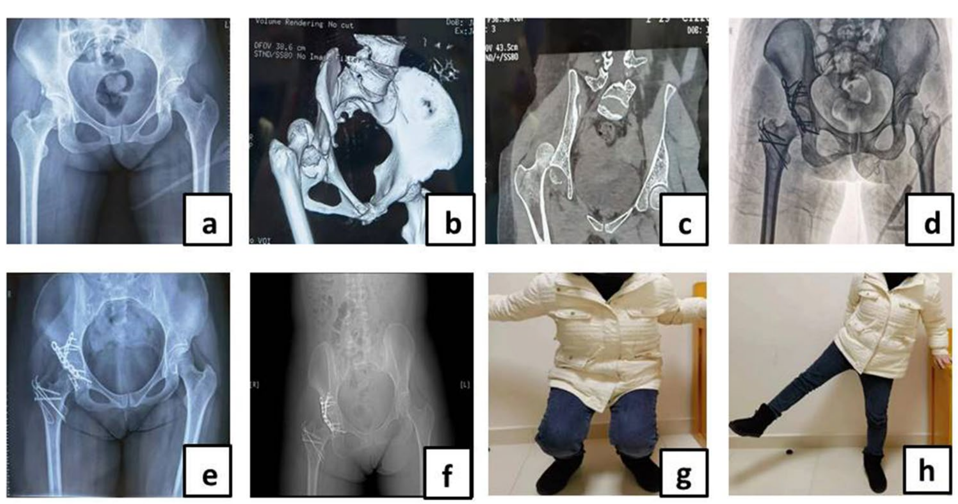

Fig. 2 A 28-years-old female, who sustained a road traffic accident and presented with right Pipkin IV femoral head fracture: (**a**) preoperative X-ray image of the; (**b**) 3D CT showed fracture of the femoral head with fracture of the posterior wall of the acetabulum; (**c**) 2D CT scan coronal section showing posterior dislocation of the fractured femoral head; (**d**), (**e**) and (**f**) reveal the postoperative radiographic images at respectively one day, three months and one year. (**d**) and (**h**) demonstrate a good hip function at one year follow-up

Table 1 Demographic data of our cases

Case	Age	Sex	MOI	SOI	Type of fixation	Follow-up (months)	HHS		Modified Merle d'Aubigne and Postal Score	Complication
							One year follow-up	Last follow-up		
1	45	M	RTA	L	4.0 mm cannulated screw	58	85 (Good)	90 (Excellent)	Excellent	
2	35	M	RTA	L	Herbert screw	55	85 (Good)	95 (Excellent)	Excellent	
3	31	M	RTA	R	4.0 mm cannulated screw	51	80 (Good)	95 (Excellent)	Excellent	
4	28	F	RTA	R	2.7 mm cannulated screw	48	90 (Excellent)	90 (Excellent)	Excellent	
5	39	M	Fall from height	L	4.0 mm cannulated screw	37	85 (Good)	60 (Poor)	Poor	osteonecrosis
6	32	F	RTA	R	4.0 mm cannulated screw	57	90 (Excellent)	100 (Excellent)	Excellent	
7	48	M	RTA	R	2.7 mm cannulated screw	43	75 (Fair)	85 (Good)	Good	
8	27	M	RTA	R	4.0 mm cannulated screw	39	80 (Good)	100 (Excellent)	Excellent	
9	42	F	RTA	L	Herbert screw	40	85 (Good)	85 (Good)	Good	
10	40	M	RTA	L	2.7 mm cannulated screw	39	85 (Good)	95 (Excellent)	Excellent	
11	36	F	RTA	R	4.0 mm cannulated screw	35	90 (Excellent)	100 (Excellent)	Excellent	
12	41	M	RTA	R	4.0 mm cannulated screw	32	85 (Good)	95 (Excellent)	Excellent	
13	29	M	Fall from Height	R	4.0 mm cannulated screw	44	90 (Excellent)	95 (Excellent)	Excellent	
14	51	F	RTA	R	4.0 mm cannulated screw	41	80 (Good)	85 (Good)	Good	
15	42	F	RTA	L	Herbert screw	46	90 (Excellent)	90 (Excellent)	Excellent	
16	33	F	RTA	R	2.7 mm cannulated screw	38	70 (Fair)	80 (Excellent)	Excellent	
17	37	M	RTA	R	4.0 mm cannulated screw	24	85 (Good)	100 (Excellent)	Excellent	
18	43	M	Fall from Height	L	Herbert screw	22	75 (Fair)	85 (Good)	Good	
19	38	M	RTA	R	Herbert screw	33	75 (Fair)	75 (Fair)	Fair	osteonecrosis
20	28	F	RTA	R	2.7 mm cannulated screw	23	85 (Good)	90 (Excellent)	Excellent	
21	44	M	RTA	L	Herbert screw	19	80(Good)	90 (Excellent)	Excellent	

Discussion

The surgical approach for the management of femoral head fractures remains a subject of ongoing debate [14, 15, 17]. The primary conventional approaches for femoral head fracture management include the Smith-Petersen approach, Kocher-Langenbeck approach, combined anterior and posterior approaches, and the Ganz approach [17]. The Smith-Petersen approach provides direct access to the anterior aspect of the femoral head; however, it is challenging to achieve complete exposure of the femoral head. Additionally, the incidence of heterotopic ossification is relatively high with this anterior approach [10]. The Smith-Petersen approach is believed to compromise the remaining blood supply to the femoral head, which led to the frequent use of the Kocher-Langenbeck approach for managing Pipkin fractures in the past [18–20]. The Kocher-Langenbeck approach provides good visualization for exposing the hip joint, allowing for repair of the acetabular posterior wall fracture and joint capsule, as well as reduction and fixation of femoral head fractures. However, it is limited in addressing anterior and inferior femoral head fractures, which cannot be adequately reduced and fixed under direct vision. Since most Pipkin IV fractures involve anterior and inferior femoral head fractures combined with acetabular posterior wall fractures, the traditional Kocher-Langenbeck approach is not ideal for treating Pipkin IV fractures. Research has indicated that a combined direct anterior and posterior approach yields satisfactory clinical outcomes for the management of Pipkin IV fractures [21]; However, due to the increased extent of trauma associated with this approach, data on its use in the treatment of Pipkin IV fractures are limited in the literature.

The literature supports that the round ligament is not the primary source of blood supply to the femoral head [19, 22], therefore, the removal of the remaining round ligament does not significantly impact the blood supply to the femoral head. Additionally, the deep branch of the medial circumflex femoral artery serves as the critical source of blood supply to the femoral head. Given the vascular characteristics of the femoral head, both the anterior and posterior approaches can exacerbate vascular injury to the femoral head, thereby compromising its blood supply [23].

Based on a comprehensive study of the blood supply to the femoral head, Ganz et al. [16] used greater trochanter osteotomy, released the abductor muscle group, and fully dislocated the femoral head, allowing direct visualization of the entire hip joint. Hosny et al. [24] recently reported satisfactory results with low complication rate in a series of 18 cases of femoral head fracture treated by Ganz surgical dislocation. Mauro et al. [17] in their series of nine patients, treated by Gibson's approach using surgical hip dislocation through Ganz trochanteric osteotomy, reported excellent result after evaluation of clinical outcome. In 2018, Trikha et al. [25] reported lower rates of complications in a series of patients presenting acetabular or femoral head fractures all treated through trochanter osteotomy and dislocation of the hip, with good clinical outcomes; Khalifa et al. [26] reported excellent and good clinical outcomes in 25 patients; all were treated via surgical hip dislocation.

A posterior wall fracture is typically associated with concurrent intra-capsular injury to the posterior labrum. Osseous avulsion of the posterior root of the labrum is an indication for surgical repair, as it can lead to joint instability by disrupting the normal sealing function of the joint [27]. Solberg et al. [28] found labral disruption (in the superior acetabular rim) in all patients in their series of 12 patients; another study reported labral tears in approximately 53.5% of patients. The authors noted that these tears were primarily located at the posterosuperior region of the acetabular rim. Additionally, they emphasized that these labral tears could be effectively assessed and repaired using the posterior surgical dislocation technique [29]. In the current study, a labral tear was identified in all patients, and intraoperative surgical repair was performed using anchor sutures. However, in patients with severe labral lesions, the only viable option was simple trimming of the labral edges.

Various fixation methods for femoral head fractures have been reported in the literature. Partial cancellous screws are effective for specific fracture patterns [26, 30, 31], while nonabsorbable screws provide stability and long-term alignment maintenance [14]. The Herbert screw, a cannulated non-absorbable screw, offers stable fixation through its lag-screw mechanism and compression capability [28, 30–32]. Additionally, headless screws, which minimize irritation and impingement, are beneficial for maintaining compression and promoting bone healing [28, 29]. In this study, partial cancellous screws and Herbert screws were used in 15 and six cases, respectively. Some authors suggest that cannulated cancellous screws may offer greater compression than Herbert screws, potentially improving fracture stability and promoting better bone healing [33]. We believe that screw diameter selection should be based on the size of the fractured fragment. Whether using a 4 mm–2.7 mm cannulated screw, the primary consideration should be achieving rigid compression to prevent displacement and ensure optimal fracture healing.

Postoperative functional outcome can be evaluated by using either Merle d'Aubigne and Postal score [26, 29–32] or Harris Hip Score (HHS) [14, 26, 34, 35]. In the current study, both the Merle d'Aubigné and Postel score and the Harris Hip Score (HHS) were used to assess the functional clinical outcome. Despite the overall positive clinical results, two patients in our series developed osteonecrosis, which was managed surgically with hip arthroplasty.

Femoral head fractures increase the risk of avascular necrosis due to vascular injury, with reported osteonecrosis rates after traumatic hip dislocation ranging from 8 to 24% [14, 29, 30]. Studies suggest a strong association between Pipkin IV fractures and avascular necrosis [2, 32]. Solberg et al. [28] reported one case of osteonecrosis in a series of 12 Pipkin IV fractures. Intraoperative drilling is essential for assessing femoral head vascularity, and timely hip reduction minimizes osteonecrosis risk [29]. In our study, two patients (9.5%) developed osteonecrosis despite negative drilling tests, leaving its correlation with fracture type or test results unclear.

Prompt closed reduction within 6 h and early surgery (24–48 h) may have contributed to the low incidence of femoral head osteonecrosis. The intraoperative drilling test is a reliable predictor of femoral head viability, with a sensitivity and specificity of 83–97% [36, 37]. According to Aprato et al. [36] the sensitivity and the specificity of the drilling test ranges between 83% and 97%. The negative drilling test reports a potentially high risk of osteonecrosis. In our study, both cases that developed osteonecrosis had negative drilling tests, supporting its reliability in guiding treatment decisions between open reduction and internal fixation (ORIF) and hip arthroplasty.

In contrast to other research papers [28, 29, 32], our study did not report complications such as heterotopic ossification, hip osteoarthritis, or infection. The Ganz approach offers full hip joint exposure, providing an 11 cm safe operating space around the femoral neck and 360° visualization of the femoral head, neck, and acetabulum. This allows direct removal of loose debris, repair of acetabular fractures and labral tears [24] and preservation of extracapsular femoral head blood supply. Given these advantages, we utilized the Ganz approach for 21 Pipkin IV fracture cases to further assess its suitability for this fracture type.

During the procedure, protecting the deep branches of the medial circumflex femoral artery is essential. While the round ligament may be sectioned if needed, excessive tightening of sutures within the joint capsule should be avoided to prevent compromising femoral head blood perfusion.

Limitations

The retrospective design and absence of a control group may introduce bias, highlighting the need for randomized controlled trials to confirm clinical efficacy. Additionally, the small sample size limits the ability to draw definitive conclusions. The short follow-up period may not capture all potential postoperative complications beyond one year. A longer follow-up in future studies will be necessary to comprehensively assess long-term outcomes.

Conclusion

The Ganz approach provides complete exposure of the hip joint and femoral head while preserving the blood supply to the femoral head. In this study, the Ganz approach yielded satisfactory clinical outcomes in the treatment of Pipkin IV fractures, demonstrating its potential for widespread clinical application.

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Author contributions
Conception and study design: G.R.K. and Z.W.W; acquisition of data: Z.W.W and J.L.Z; analysis and interpretation of data: G.R.K., Z.W.W; drafting of the manuscript: G.R.K, Z.W.W; critical revision: M.C, Z.W.W. All the authors read and approved the final version of this manuscript.

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

Declarations

Ethics approval and consent to participate
This study was performed in line with the principles of the Helsinki declaration of 1975. This study was approved by the Institutional Review Board and the Ethics Committee of The first affiliated hospital of Nanchang University (Date-number: 2023 – 220). All patients provided informed consent prior to their participation in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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