Management of a Pipkin Type III Femoral Head Fracture Via Ganz Approach with a Cannulated Lag Screw & Herbert Screw

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Research Article

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Abstract

Objective:

To evaluate the medium - to long-term efficacy of a Ganz approach and cannulated lag screw combined with Herbert screw, in the management of a Pipkin type III femoral head fracture.

Methods:

Retrospective analysis was performed on 11 patients (6 males, 5 females) who sustained Pipkin type III femoral head fractures and were managed with a cannulated lag screw, combined with Herbert screw, inserted using the Ganz approach and who were admitted to our department between June 2018 to June 2020. Perioperative indicators, postoperative function and follow-up complications at 9 months after surgery, Harris score at 6 and 9 months after surgery, Thompson-Epstein score, hip femoral head necrosis and incidence of post traumatic hip arthritis were analysis.

Results:

10 patients completed follow-up, with an average follow-up time of (13.7 ± 2.1) months. The mean operative time was (100.3 ± 23.67) minutes, intraoperative blood loss was (138.6 ± 50.18) ml, peripheral blood hemoglobin (Hb) was (105.6 ± 18.94) g/L 24 hours after surgery, and the complication rate was 1/10 2 weeks after surgery. The Harris Hip Scores for joint function at 6 and 9 months after the operation were (68.6 ± 5.49) points and (88.8 ± 5.77) points respectively. The excellent and good rate in the last follow-up was 80% (Thompson-Epstein score). The complication rate was 10%.

Conclusion:

A cannulated lag screw combined with a Herbert screw and inserted via the Ganz approach, is an effective method for the treatment of Pipkin type III fractures.

Highlights

1. Pipkin's type fracture is a very rare type of fracture, which is complex and has a low success rate, and there is currently no highly successful technique to ensure that the operation is successful.
2. In the present study, we reported that a cannulated lag screw combined with a Herbert screw and inserted via the Ganz approach, is an effective method for the treatment of Pipkin type III fractures. Furthermore, has the advantage of easy surgical exposure, high rates of excellent and good postoperative outcomes, low complications, and is a reliable surgical approach.
3. To our knowledge, this is the first paper to investigate via Ganz approach with a cannulated Lag Screw & Herbert Screw to treat Pipkin III Femoral Head Fracture and got successful.

Introduction

Fractures of the femoral head occur relatively frequently, accounting for approximately 7% of hip fractures, and are associated with having high disability rates [1, 2]. The common etiology of the is high energy impact injuries of the lower extremities while with the hip in a position of flexion, often accompanied by the posterior dislocation of the hip joint, fractures of the acetabulum or fractures to the proximal femur. Posterior dislocation of the femoral head is associated with a fracture of the femoral head in 7% to 15% of cases[1]. Classifications of femoral head fractures include the Pipkin, AO, and Brumbaek [2, 3] criteria, with the Pipkin classification being the most commonly used clinical classification method, utilized approximately 68% of the time[4]. The femoral head and the acetabular fossa constitute the hip joint, which is responsible for dividing the mechanics and weight bearing of the longitudinal axis of the human body into two parts, and plays a key role in human mobility. Dysfunction of the hip joint can significantly affect the quality of life of patients [2]. Pipkin type III femoral head fractures result in an uneven articular surface of the hip joint and impair blood supply to the femoral head, making it prone to complications such as post traumatic hip arthritis and avascular necrosis of the femoral head [5, 6].Therefore, surgery is performed to restore the anatomical structure of the femoral head, especially when the fracture is displaced. However, the current surgical management of femoral head fractures still requires surgical exposure, reduction, and fixation, and can still lead to postoperative femoral head necrosis and post traumatic arthritis. At present, the clinical diagnosis of a femoral head fracture is primarily confirmed by combining medical history, physical signs and imaging investigations. Typical fractures of the femoral head, such as Pipkin III, can usually be diagnosed on hip X-rays, however, for obscure fractures of the femoral head, such as Pipkin I, a single X-ray examination within 3 days of fracture is unlikely to reveal the fracture and may lead to a missed diagnosis that is then treated conservatively. Utilizing CT or MRI scans in investigations can greatly improve the diagnosis rate [7].

Currently, the treatment options for femoral head fractures primarily include early initial closed reduction, with conservative treatment using traction systems, open reduction and internal fixation, and joint replacement [8]. These three management approaches have relative indications, and the clinical choice needs to consider the patient's treatment expectation and medical technology and expertise available when weigh up management options. For Pipkin type 1 fractures with no obvious fracture line, lower limb braking and traction without weight-bearing, can achieve good curative effect. Of course, timely and accurate diagnosis is the key to successful conservative management. It has previously been reported that closed reduction with percutaneous K-wire fixation has achieved good results in the treatment of Pipkin type I fractures[9]. However, for Pipkin Type II-IV fractures, surgical treatment is the first option, to avoid avascular necrosis, post traumatic arthritis and to restore hip function. [10] Good exposure and reliable fixation of femoral head fractures are key to ensuring hip function. [11] Since the anatomical structure of the femoral head determines whether it can be repaired with countersunk screws, there seems to be consensus on the principles of fixation of Pipkin type I and type II fractures in the absence of neck of femur fractures [12]. However, in the presence of avascular necrosis of the femoral head, associated complications in using screw fixation can only be avoided and reduced by improving the surgical technique applied. Current surgical approaches for femoral head fractures vary and include the medial approach (Ludloff approach) and the anterior approach (Smith Petersen approach), the antero-medial

fenestration approach, the Watson-Jones Approach, the lateral approach and the Kocher-Langenbeck approach [13-16]. Despite these options, it remains a challenge to easily expose the femoral head and complete the reduction and fixation under direct vision. Therefore, the current difficulties and controversies in the treatment of Pipkin type III fractures are primarily focused on how to optimize surgical exposure. The Ganz greater trochanteric osteotomy has been used in previous studies to treat Pipkin type I and type II with good results [17-19]. This provided the inspiration for us to use this approach in combination with the countersunk screws to treat more severe Pipkin type III fractures. The acetabular dislocation technique, also known as the Ganz osteotomy, was first proposed by Ganz[20] in 2001. It makes use of a pendulum saw to make a 1.5cm thick osteotomy under the great trochanter to remove the insertion site of the gluteus maximus and gluteus medius muscles from the anterior to the posterior, allowing the proximal femur to be externally rotated to expose the acetabular fossa and femoral head. Since this approach avoids the medial circumflex femoral artery of the femoral neck, when performed with good surgical technique, it will not affect the blood supply of the femoral neck. There is however the risk of possible nonunion of the osteotomy and heterotopic ossification [21]. There are limited reports on the use of a greater trochanteric osteotomy in the treatment of Pipkin type III fractures of the femoral head.

To address the challenges of exposure and fixation of Pipkin Type III fractures, we used the greater trochanteric osteotomy approach (Ganz approach) to expose the femoral head, a cannulated tension screw to fix the femoral head and femoral neck, and a countersunk Herbert screw to fix the femoral head fragments. Through this approach we found that the femoral head could easily be exposed and fixed intraoperatively, with improved reduction under direct vision and better control of the screw depth and placement. The complication rates including avascular necrosis of the femoral head and perforation of the femoral head screws during long-term follow-up remained low.

Methods

General information of the patient

Ten cases of Pipkin type III fractures were diagnosed in the Department of Orthopedics at Wuhan Union Hospital affiliated to Tongji Medical College of Huazhong University of Science and Technology, from June 2018 to June 2020 and were retrospectively analyzed, and included 6 male and 4 female patients. Mechanism of injury included, 7 cases of road traffic accidents, 2 cases of a fall from height and 1 case of a sports injury. The mean age was (36.55+2.71) years old. All the surgeries were performed with the Ganz approach (greater trochanteric osteotomy) with fixation performed using cannulated screws that were combined with Herbert screws.

Inclusion and exclusion criteria

The inclusion criteria included:

1. Simple closed fracture of the femoral head and classified as Pipkin Type III

2. Ganz approach (with osteotomy through the greater trochanter) was adopted as the method of exposure, and fixation was conducted with a cannulated lag screw combined with a Herbert screw
3. Patients were aged between 18 years old and 60 years old
4. The operation was performed by the same medical team

The exclusion criteria included:

1. Presence of other fractures sites
2. Open femoral head fracture
3. The operative technique did not include the Ganz approach (greater trochanteric osteotomy) and the fixation did not utilize a cannulated lag screw combined with a Herbert screw.
4. Patient is older than 60 years or younger than 18 years old

Preoperative management of patients

After the patient was admitted to hospital, the patient underwent external reduction as soon as possible, with skin traction being applied using $1/10^{th}$ of the patient's body weight to apply longitudinal traction force. Analgesia and anticoagulant therapy were administered while X-ray's and CT examinations of the hip joint were obtained, and cardiopulmonary function, coagulation function, blood routine, C-reactive protein and other preoperative routine examinations were monitored and optimized accordingly.

Surgical approach and fixation

After general anesthesia, the patient is placed in the lateral decubitus position. The sterile surgical site included the area 5cm distal from the posterior superior iliac spine to the greater trochanter of the femur. The skin and subcutaneous fascia were incised and dissected layer by layer, exposing the tensor fascia lata and the gluteus maximus space, with enterry along the modified muscle space, to expose the gluteus medius and gluteus minimus muscles at the greater trochanter insertion site. Osteotomy was performed 1.5cm below this insertion site on the greater trochanter of the femur, and attention was given to ensure protection of the llihypoqastric nerve and the lateral femoral circumflex artery. The insertion point of the gluteus intermediate and gluteus minimus muscle was subsequently displaced superiorly. The joint capsule was incised in a Z-style, and the affected limb was then adducted and externally rotated, while the hip joint was dislocated. This allowed for the fractured femoral head to be reduced under direct vision, and the Kirschner wire was used for temporarily fixation, while the Herbert screw was inserted along the Kirschner wire for countersunk fixation. Three cannulated lag screws were inserted in an isosceles triangle from the lateral side of the lesser trochanter of the femur through the femoral neck to fix the femoral head. The femoral head was relocated into the acetabulum, the joint capsule was sutured, and the greater trochanteric osteotomy was fixed with two or three tension screws. After the fluoroscopic reduction was deemed satisfactory, the range of motion of the hip joint was evaluated to determine the effectiveness of the fixation. If satisfactory, hemostasis was confirmed and rinsing was performed, before completion of the operation with layer by layer suture closure.

Postoperative treatment

Within 24 hours after surgery, the affected limb was fixed with “T shoes, and the patient was routinely given Dezocine Injection (0.8 mg/kg, Bid) for pain relief for 24 hours. On the third day after surgery, change to oral Indomethacin (25 mg/time, PRN) was given according to the patient’s pain perception. Omeprazole Sodium (1.25mg/kg, Bid) was given to protect the digestive tract and Flucloxacillin Sodium (500mg, Bid) was given to prevent postoperative infection same as intraoperative used. On the second day, the patient was instructed on how to exercise the quadriceps femoris muscle and calf muscle group using isometric contraction in bed to assist prophylaxis lower limb thrombosis. On the third day after the operation, straight leg raising and adduction exercises were performed in bed. Dependent on the patient’s perception, 5-7 days after the operation, they were helped down to the ground start training, and follow-up hip X-rays were reexamined. Ten days after surgery, the sutures were removed, and the patient discharged from hospital. Patients were able to commence partial weight-bearing on the affected limb from 1 month after surgery, and full weight bearing after three months post-surgery.

Obtaining and evaluating the observation indexes

1. Perioperative indexes measured

Operation time: Operation time shall be subject to the theatre time recorded in this case; Intraoperative blood loss was calculated by using the weight difference of hemostatic gauze before and after the use together with the blood volume estimate in from the suction cannister. The difference in hemoglobin volume between preoperative and postoperative interval at 24 hours was obtained from the electronic medical record system. The incidence of postoperative wound complications was obtained by referring to the patient's postoperative nursing record sheet.

2. Follow-up indexes of postoperative function and complications

The healing rate of the femoral head, necrosis rate of the femoral head, and the incidence of heterotopic ossification of the hip at 9 months post-surgery were confirmed upon review of the patient's outpatient follow-up records and X-rays, and the Thompson-Epstein score was also calculated using these X-rays[22].

Hip function was evaluated using the Harris score at 6 and 9 months post-surgery [23]. Determination of osteonecrosis of the femoral head and post-traumatic arthritis of the hip at the last follow-up were evaluated using anteroposterior and lateral hip X-rays [24].

Statistical method

Enumeration data were expressed as mean ± standard deviation, measurement data were expressed as percentages, and differences in pre- and post-operative hemoglobin were analyzed using a paired T test, $p<0.05$, was deemed to be statistically significant. Analysis was conducted using SPSS 20.0 and GraphPad Prism7 plotting software.

Results

One male patient was lost to follow-up and was excluded from the study, with the other 10 patients completing follow-up. The mean follow-up time was (13.7 ± 2.1) months. Perioperative indicators: mean operative time (100.3 ± 23.67) min, intraoperative blood loss (138.6 ± 50.18) ml, difference in postoperative blood hemoglobin (7 ± 15.60) g/L, wound complication rate of 1/10 (10%) 2 weeks after surgery; The Harris hip score at 6 and 9 months after operation were (68.6 ± 5.49) points and (88.8 ± 5.77) points respectively. The excellent and good rate (Thompson-Epstein score) in the last follow-up was 80%. The Thompson-Epstein score of the hip X-rays were classified as excellent in 6 cases, good in 2 cases, medium in 1 case and poor in 1 cas**e.**

Review of a typical cases

The patient was a male, 26 years old, who sustained a left sided femoral head fracture due to a road traffic accident and was placed in skin tractionof the affected limb once admitted, with fixed “T” shoes. A hip X-ray and CT evaluation found the fracture to be a Pipkin type III fracture. The fracture was then reduced manually. His cardiopulmonary function was assessed for any surgical contraindications, consent was obtained from the patient. The surgery was performed under general anesthesia using the Ganz approach. The greater trochanter was exposed with layer by layer incision and dissection along a line extending from the greater trochanter to the posterior superior iliac spine. Osteotomy of the great trochanter of the femur was performed approximately 1.5cm from the insertion site of the intermediate gluteus and gluteus minimus muscles. The limb was adducted and externally rotated allowing the femoral head to be dislocated and exposed. The femoral head fragment was fixed with a Herbert screw, while the femoral head and femoral neck were then fixed with a cannulated lag screw. The femoral head was then relocated in the acetabulum and the great trochanteric osteotomy was repaired with two lag screws (Figure 2). The functional status of the hip joint evaluated based on its range of movement to confirm the fixation of the osteotomy (Video 1). The surgical site was washed out and layer-by-layer suturing performed. Follow-up reexamination was performed on the third day after surgery, 6 and 9 months after surgery (Figure 3). Follow-up revealed the fracture had healed correctly and the hip joint function was restored. No avascular necrosis of the femoral head was noted nor had any post traumatic arthritis been noted (Figure 3).

Discussion

Complicated femoral head fractures such as Pipkin type III and type IV fractures present various difficulties in the orthopedic management of trauma. How to effectively reduce the incidence of femoral head necrosis, post-traumatic arthritis and heterotopic ossification remains the primary focus for orthopedic trauma surgeons[25]. Over the past two decades, many case studies have reported a large variance in the excellent and good outcome ratings when following up femoral head fractures. A retrospective analysis by John A Scolaro et al[26] found that all included Pipkin type III failed internal fixation, and 89.9% of types I to II healed successfully. In general, Pipkin type I and II surgery has better

outcomes than type III or IV fractures[27]. Pipkin type I and II fixation methods tend to use countersunk screws, and the approach tends to be anterior, while the surgical approach and fixation methods of Pipkin type III and IV remain controversial.

Anatomical reduction of femoral head fractures is vital to successful healing of the fracture and is the most difficult aspect to master in the management of these fractures. The premise of reduction relies on good exposure of the femoral head. The purpose of choosing different surgical approaches is to gain the closest access to the fracture site, and most importantly for better exposure. The current surgical approaches for femoral head fractures include the medial approach (Ludloff approach), the anterior approach (Smith Petersen approach), the anterolateral approach (Watson-Jones approach), the lateral approach and the posterior approach (Kocher-Langenbeck approach)[28]. Despite all these approaches, it remains difficult to easily expose the femoral head and complete the reduction and fixation of the femoral head under direct vision. In addition, when considering the impact of the surgical approach on exposure, it is also necessary to consider the impact of the approach on adjacent blood vessels, muscles, and nerves. Since the Pipkin type Ⅳ fracture is often combined with a femoral neck fracture, the possibility of postoperative femoral head necrosis is very high. It is for this reason that many studies recommend hip replacement[29, 30]. At present, the surgical approach and fixation methods for Pipkin type III fractures remains controversial.

Among the 10 patients included in the study with Pipkin type III fractures, the overall excellent/good rate reached 80%, with higher treatment outcomes than in previous studies. Heterotopic ossification occurred in 1 patient (10%), which may be related to the early onset of rehabilitation training together with indomethacin after surgery[31, 32]. Furthermore, post-traumatic hip arthritis occurred in 1 patient, with a lower incidence rate than previously reported[33]. No necrosis of the femoral head was observed during the observation period. We believe that this was due to the full exposure provided by the greater trochanteric osteotomy in the Ganz approach, which allowed for accurate anatomical reduction under direct vision during the operation, and directly restored the smoothness and integrity of the surface cartilage of the femoral head. In addition, the use of filling-autogenous bone to fill bone defects also plays a role in preventing the collapse and necrosis of the femoral head[34].

The limitations of this study are small sample size, short follow-up time, and retrospective analysis, which naturally impacts the validity of the study results. However, the low incidence of Pipkin type III fractures also limited the possibility for us to expand the sample size. Regardless, our results preliminarily confirm the advantage of the greater trochanteric osteotomy approach in the management of Pipkin's type III fractures.

Conclusion

The greater trochanteric osteotomy used in the Ganz approach for the management of Pipkin type III fractures has the advantage of easy surgical exposure, high rates of excellent and good postoperative outcomes, low complications, and is a reliable surgical approach.

Abbreviations

Not applicable

Declarations

Ethics approval and consent to participate

All patients were obtained with signed informed consent and approved by the Medical Ethics Management Department of Tongji Medical College of Huazhong University of Science and Technology (Ethics approval number: No. [2018] S431).

Consent for publication

The manuscript has not been published elsewhere and is not being considered for publication by any other journal or by other language.

All authors have read and approved this paper, as well as contributed to its content. All authors declare that they have no competing financial interests.

Availability of data and materials

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

Competing interests

All authors declare that they have no competing financial interests

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Authors' contributions

L.H., M.L., and G.L. study conceived and designed. X.D., H.X., Z.L., B.M., G.L., M.L., L.C., Y.H., R.Y., C.Y. and W.Z. performed the operation. L.H., X.D., Y.S., and G.L. analyzed the data. X.X., J.L., H.X., T.W., and Z.L. contributed analysis tools. D.X, and G.L. performed statistical analyses. L.H., X.D. and G.L.J. wrote the manuscript. All authors read and approved the manuscript.

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Authors' information (optional)

Not applicable

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Tables

Table 1
General characteristics of the include patients.

Patient	Age (Yeras)	Gender	Injury mechanism	Pipkin Classification	Follow-up (Month)	Operatinve duration(min)
1	23	Male	Traffic accident	Type □	11	65
2	25	Male	Fall	Type □	12	78
3	35	Female	Traffic accident	Type □	13	87
4	44	Female	Traffic accident	Type □	18	123
5	56	Male	Traffic accident	Type □	12	112
6	35	Female	Fall	Type □	11	85
7	46	Male	Traffic accident	Type □	12	87
8	35	Female	Traffic accident	Type □	15	104
9	28	Male	Traffic accident	Type □	13	112
10	30	Male	Fall	Type □	11	150

Table 2
The clinical outcomes of the included patients.

Item	Perioperative	Follow-up (6 months)	Follow-up (12 months)
Intraoperative blood loss(ml)	138.6 ± 50.18	-	-
Difference in postoperative blood hemoglobin (g/L)	7 ± 15.60	-	-
Wound complication rate (g/L)	0	0	10%
Harris hip score	-	68.6 ± 5.49	88.8 ± 5.77
Thompson-Epstein score	-	-	80%

Figures

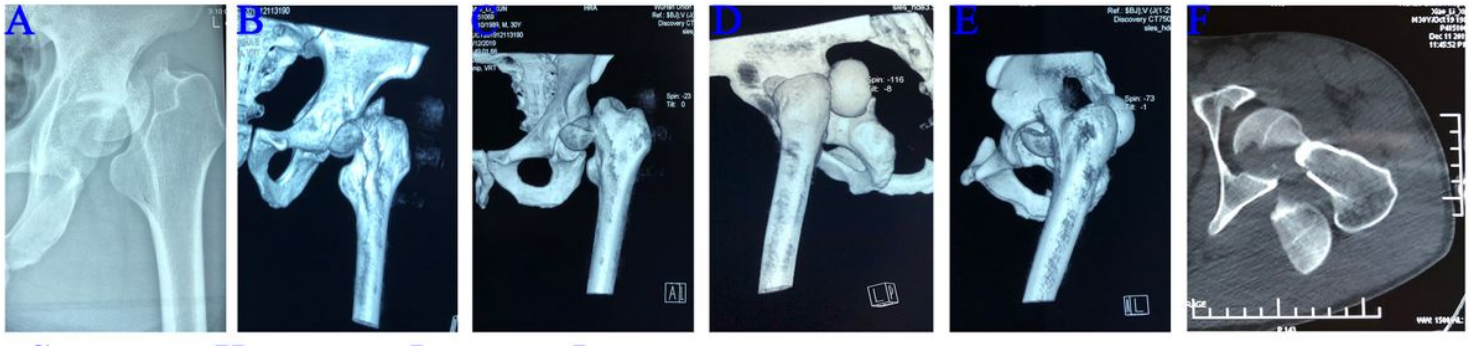

Figure 1

X-ray and CT results of the hip 24 hours after fracture. A. Anterophorical hip position shows fracture of femoral head and neck, classified as type according to Pipkin classification. B-E. CT scan reconstruction of the hip showed no acetabular fracture. F. CT scan of the hip joint showed fracture of femoral neck and femoral head.

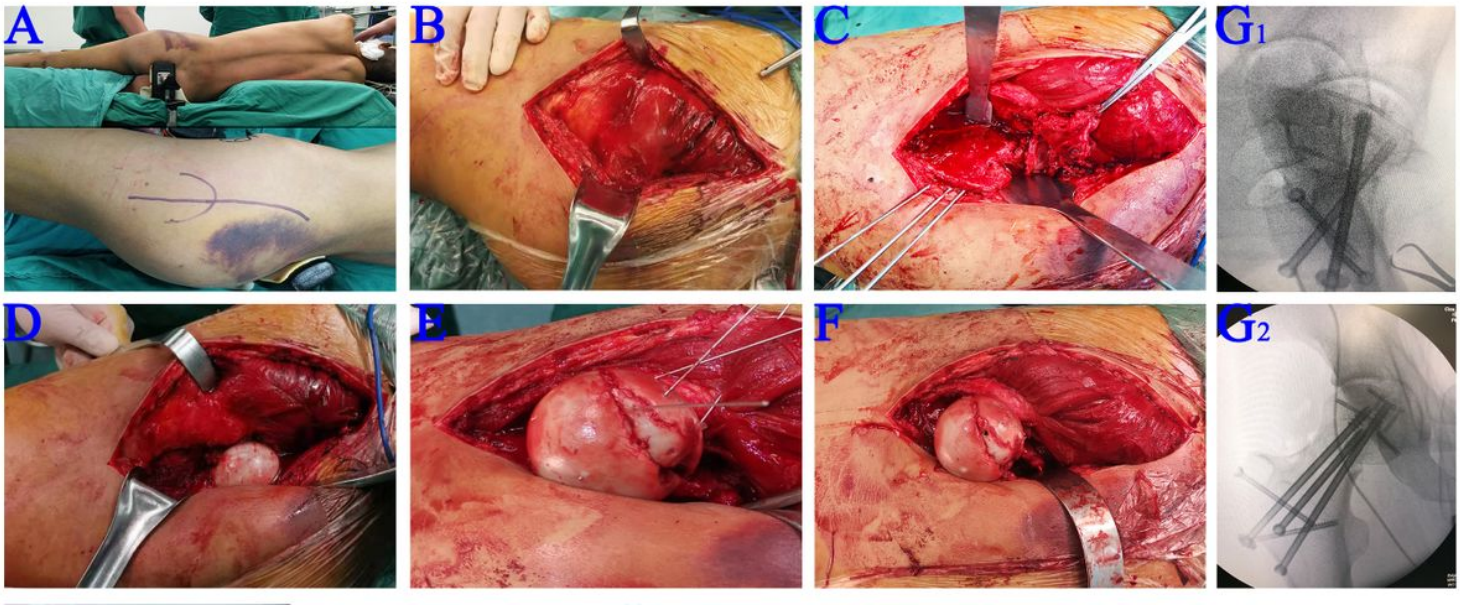

Figure 2

Surgical process of Ganz approach for femoral head fracture. A. Place the patient in side decubitus position and mark the location of the surgical approach. B-F. Surgical exposure of the femoral head and process of reduction. G1-2. Timely postoperative bedside X-ray examination showed good reduction and effective fixation.

Figure 3

Results of hip reexamination at 6 and 13 months after surgery. A. The hip fracture healed well 6 months after the operation B. Thirteen months after the operation, the hip joint was well reduced, no necrosis of the femoral head, no arthritis of the hip, no heterotopic ossification C-F. Hip function was normal 13 months after surgery.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Video1.mp4