

Original Article

Middle-term follow-up results of Pipkin type IV femoral head fracture patients treated by reconstruction plate and bioabsorbable screws

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ABSTRACT

Purpose: To investigate the mid-term curative effects of the treatment of Pipkin type IV femoral head fractures using a reconstruction plate and bioabsorbable screws and provide the evidence for clinical practice.

Methods: From February 2010 to September 2014, 21 patients with Pipkin type IV femoral head fractures were treated surgically. There were 13 males and 8 females with an average age of 41.1 years (range, 20–65 years). The causes of the fractures included traffic accidents (13 cases), falls from a height (four cases), heavy lifting injuries (three cases), and sport injury (one case). All patients were followed up with radiography and three-dimensional reconstruction computed tomography and other checks and any complications were actively managed. Closed reduction of fracture-dislocation of the hip was attempted under general anesthesia using the Kocher-Langenbeck approach. Femoral head fractures were treated with internal fixation or excision based on the size of the fracture fragments, whereas acetabular fractures were fixed with a reconstruction plate and screws following anatomic reduction.

Results: The incisions healed by primary intention in all patients after surgery, without any infection, deep venous thrombosis, or other complications. All 21 patients were followed up for 36–76 months, with an average follow-up duration of 49 months. Postoperative imaging data showed that all dislocations and fractures were anatomically reduced, and bony union of the fractures was achieved. Heterotopic ossification was found in four patients, post-traumatic osteoarthritis in three, and avascular necrosis of the femoral head in two. At the final follow-up, the assessment of hip joint function according to the Thompson-Epstein scoring scale was excellent in 10 cases, good in six cases, fair in three cases, and poor in two cases. The rate of excellent and good functional outcomes was 76.1%.

Conclusion: The mid-term curative effects of a reconstruction plate and bioabsorbable screws in the treatment of Pipkin type IV femoral head fractures is significant, and such the treatment can significantly improve the patient's joint function and quality of life.

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Introduction

Fracture of femoral head is a relatively uncommon injury, which is mostly caused by high energy trauma, such as traffic accidents, falls from a height, industrial accidents, and sports injuries. In 1869, Birkett¹ firstly described the fracture of the femoral

head, which was always associated with traumatic posterior hip dislocation but the incidence was low. However the incidence of this injury has increased steadily in recent years. Based on the location of the femoral head fractures in relation to the fovea and the additional lesion on the femoral neck or acetabulum, Pipkin classification is widely used for femoral head fractures.² It is difficult to adopt open reduction and internal fixation for Pipkin type IV femoral head fractures associated with acetabular fractures, especially the posterior wall fractures of the acetabulum. Posttraumatic osteoarthritis, avascular necrosis of the femoral head and other complications are common so that the post-operative functional outcome is relatively poor.³ Reconstruction

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plate and bioabsorbable screws were widely used in the surgical treatment of Pipkin type IV femoral head fractures, which can not only restore the anatomy of the hip, but also benefit to early postoperative functional exercise. However, because of the small number of patients, the insufficient length of follow-up and the use of non-validated outcome instruments, only a few studies have been reported in the literature. This study retrospectively reviewed the clinic data of 21 patients with Pipkin type IV femoral head fractures who were treated by open reduction and internal fixation at our institution between February 2010 and September 2014. Postoperative evaluation, complications and functional recovery results were analyzed to provide a reference for the clinical treatment.

Methods

General data

There were totally 21 patients with Pipkin type IV femoral head fractures, including 13 males and 8 females with a mean age of 41.1 years (range: 20–65 years). The causes of fractures included traffic accidents (13 cases), falls from a height (four cases), heavy punch injuries (three cases), and sport injury (one case). Ten cases had the right hip affected, and 11 had the left hip affected. Femoral head fracture was combined with sciatic nerve injury in three cases, other fractures of limbs in nine, head injuries in four and thoracic injuries in four.

Preoperative preparation

In the emergency department, all patients were evaluated initially according to the Adult Trauma Life Support (ATLS™) guidelines, including an anteroposterior pelvis radiograph, CT scan and three-dimensional reconstruction. Meanwhile immediate closed reduction of the hip fracture dislocation was performed under general anesthesia, and then the skeletal traction was given to maintain the reduction.

Surgical technique

Under general anesthesia, the patient was in the lateral decubitus position on the contralateral side on a standard operation table, draped in a manner to allow free movement of the injured limb. A Kocher-Langenbeck incision was made and the fascia lata was incised in line with the skin incision. The posterior border of the gluteus medius and minimus were identified and retracted to expose the posterosuperior aspect of the hip capsule. This was facilitated by abduction and internal rotation of the limb. The piriformis tendon was tagged and released but the short external rotators (quadratus femoris and obturator internus) were preserved. The sciatic nerve was revealed and protected. And neurological exploration was performed in patients with sciatic nerve injury. After blunt dissection by periosteal elevator, the Hohmann retractors were used to retract the gluteus maximus, short external rotators and sciatic nerve medially. As the femoral head was dislocated posteriorly at the time of injury, the posteroinferior capsule was found to be seriously torn, such that repair of the capsule with a heavy suture was necessary to prevent further inferior extension at the time of surgical dislocation. The capsular rent was extended directly toward the acetabular rim, and then the capsule was released off the rim anteriorly or posteriorly as needed. With a gentle blunt dissection, the posterior wall of acetabulum was released and protected, then the hip was slowly and gently dislocated by flexion, adduction and internal rotation. Small or comminuted fragments of the femoral head which remained in the

acetabulum were removed, the large fragments or fragments within the weight-bearing portion of the head should be reduced anatomically and temporarily fixed with Kirschner wires, which were sequentially replaced with bioabsorbable screws. The heads of the screws were countersunk below the cartilage level. Any soft tissue attachments to the bone fragment were preserved to prevent further damage to the blood supply of the femoral head. The acetabular fracture was reduced anatomically and then fixed with reconstruction plate plus screws to restore the congruency and stability of the hip. The repaired femoral head was then gently reduced after careful retracting the cut edges of the capsule. The capsular tear was repaired, piriformis tendon was reattached and all muscle tears were repaired. Finally, the wound surface was closed in layers after placement of a drain tube.

Postoperative care

Intravenous antibiotics were given to prevent infection in 24 h after the operation and low-molecular-weight heparin was given to avoid deep venous thrombosis. The drain tube was removed in 24–48 h postoperatively. Generally, the patients were encouraged to perform functional exercises of quadrates femoris muscles on the second day after operation while the skeletal traction was maintained until one month after operation. All patients were instructed to continue non-weight bearing for 6–8 weeks postoperatively, and then gradually shifted from partial to full weight bearing. Radiographs were taken immediately and at 1, 2, 3, 6, 12 and 24 months after surgery. Once the radiographs showed a fracture healing, progressive weight-bearing and active exercises for strengthening of the abductor muscles were started.

Results

The incisions healed primarily in all patients after surgery, without infection, deep venous thrombosis and other complications. Postoperative imaging data showed that dislocations and fractures had presented anatomic reduction and bony union. All the 21 patients were followed up for 36–76 months, with an average of 49 months.

During the follow-up, three patients developed posttraumatic osteoarthritis. Heterotopic ossification (HO) was found in four patients, according to Brooker Classification⁴ (Table 1), including one in grade II, two in grade III and one in grade IV. None of the four patients with HO underwent surgical excision of the ectopic bone despite the limited hip flexion noted in the patient with grade IV. Avascular necrosis of the femoral head occurred in two patients. One of them was confirmed with avascular necrosis of the femoral head only by postoperative MRI, but presented no obvious symptoms and signs. The other complained about pain and limited motion of the hip in the second year after surgery and the imaging examination showed avascular necrosis of the femoral head. So this patient was treated by the total hip arthroplasty, achieving good functional recovery of limbs after surgery. At the final follow-up, using the Thompson-Epstein scoring scale⁵ (Table 2), the functional outcomes were excellent in 10 cases, good in 6, fair in 3 and poor in 2. The excellent and good rate was 76.1% (Table 3, Fig. 1).

Discussion

Fracture of the femoral head is a relatively uncommon injury, which typically occurs following traumatic posterior dislocation of the hip joint. According to the statistics, about 5%–15% of posterior hip dislocations have been reported to be associated with femoral head fracture.^{6–8}

Table 1
Brooker classification.

Grade	Description
Grade I	Islands of bone within the soft tissues about the hip
Grade II	Bone spurs from the pelvis or proximal end of the femur, leaving at least 1 cm between opposing bone surfaces
Grade III	Bone spurs from the pelvis or proximal end of the femur, reducing the space between opposing bone surfaces to less than one centimeter
Grade IV	Apparent bone ankylosis of the hip

Table 2
Thompson-Epstein scores.

Scale	Clinical	Radiographic
Excellent	No pain	Normal relationship between head and acetabulum
	Full range of hip motion	Normal articular cartilaginous space
	No limp	Normal density of femoral head No spur formation No calcification in capsule
Good	No pain	Normal relationship between head and acetabulum
	Free motion (75% of normal hip)	Minimal narrowing of cartilage space
	No more than a slight limp	Minimal de-ossification Minimal spur formation Minimal capsular calcification
Fair*	Pain but not disabling	Moderate narrowing of cartilage space
	Limited motion of hip, no adduction deformity	Mottling of head, areas of sclerosis and decreased density Moderate spur formation
	Moderate limp	Moderate to severe capsular calcification Depression of subchondral cortex of the femoral head
Poor*	Disabling pain	Almost complete obliteration of cartilaginous space
	Marked limitation of motion or adduction deformity	Relative increase in density of femoral head
	Redislocation	Subchondral cyst formation Sequestrae formation Gross deformity of femoral head Severe spur formation Acetabular sclerosis

* Meet one or more clinical/radiographic conditions.

Mechanism of injury

The mechanism of femoral head fractures is traumatic posterior hip dislocation.⁵ When the violence applies to the hip joint, the femoral head is pulled out of the acetabulum posteriorly because of the shearing force against the acetabular rim, leading to femoral head fracture.⁹ Generally speaking, traumatic posterior hip dislocation is resulted from an axially applied force on the femoral shaft in flexion, adduction, and internal rotation of the hip. The most common cause is the so-called dashboard injury, i.e., the knee of a passenger strikes the dashboard during a motor vehicle collision.^{9,10} The position of the leg at the time of the accident determines whether the hip dislocates with or without additional osseous lesions on the femoral head or the posterior wall of the acetabulum. If the hip flexion is greater than 60°, the contact area of femoral head and acetabular posterior wall is small, so the fracture is most likely Pipkin type I or II femoral head fracture; if the hip flexion is less than 60°, the contact surface is big, and the axial compression is more transmitted to the hip, so the patient suffers from acetabular and femoral neck fractures besides hip dislocation and fractures of the femoral head, classified as Pipkin type III and IV femoral head fracture.¹¹

Prompt reduction of the associated hip dislocation

Long-term fracture and dislocation of the femoral head will damage the blood supply of the femoral head, which will increase the incidence of avascular necrosis of the femoral head. Therefore, the prompt reduction of the associated hip dislocation not only can prevent further damage to peripheral vessels and nerves, but also reduce the incidence of postoperative avascular necrosis of the femoral head. Epstein et al.⁶ noted that reduction within 24 h obtained better results than late reduction. Chen et al.¹² reported good results with surgical reduction within 12 h, and Mcmurtry and Quaille's¹³ study further showed that the joint should be relocated within 6 h, otherwise the risk of avascular necrosis of the femoral head associated with early degenerative joint disease will increase, and the result proved the necessity of early reduction for hip dislocation.⁸

Surgical treatment

Pipkin IV femoral head fractures include posterior dislocation of the hip, femoral head fractures and acetabular fractures. Non-surgical treatment is often difficult to achieve a better effect. Because of the limitation of hospital transfer and the high cost of the long admission, this treatment has been abandoned. The surgery treatment is effective for Pipkin IV femoral head fracture, which can restore the anatomical structure of the hip joint, allow an early functional training, and promote the recovery of post-operative function. The principles of treatment include prompt reduction of the associated hip dislocation, early anatomic reduction, rigid fixation of large fragments, restoration of hip congruency and stability and removal of small and comminuted intra-articular fragments.¹⁴

Surgical approaches

The optimal surgical approach for the treatment of Pipkin type IV femoral head fractures remains controversial. Several surgical approaches have been recommended in previous studies, including anterolateral (Watson-Jones), anterior (Smith-Peterson), and posterior (Kocher-Langenbeck, Ganz) approaches.^{15–19} The main advantage of the anterior approach is the provision of good exposure of the femoral head; thus, it is more suitable for the treatment of Pipkin type I and II femoral head fractures. In such cases, it can significantly reduce operative time and blood loss, and can thereby reduce the incidence of postoperative avascular necrosis of the femoral head. However, there are apparent drawbacks as well, as a higher incidence of HO has been reported in these cases.^{11,18,20–22} Furthermore, Epstein et al.⁶ have shown that the anterior approach can further damage the remaining anterior blood supply to the femoral head after a posterior hip dislocation, although anatomic and clinical studies do not support this theory.^{15,23,24} Swiontkowski et al.²¹ compared the anterior and

Table 3
Final functional evaluation and complications [n (%)].

Thompson-Epstein Scale	
Excellent	10 (47.6)
Good	6 (28.5)
Fair	3 (14.2)
Poor	2 (9.5)
Complications	
Traumatic sciatic nerve injury	3 (14.2)
Posttraumatic osteoarthritis	3 (14.2)
Heterotopic ossification	4 (19.0)
Avascular necrosis of the femoral head	2 (9.5)

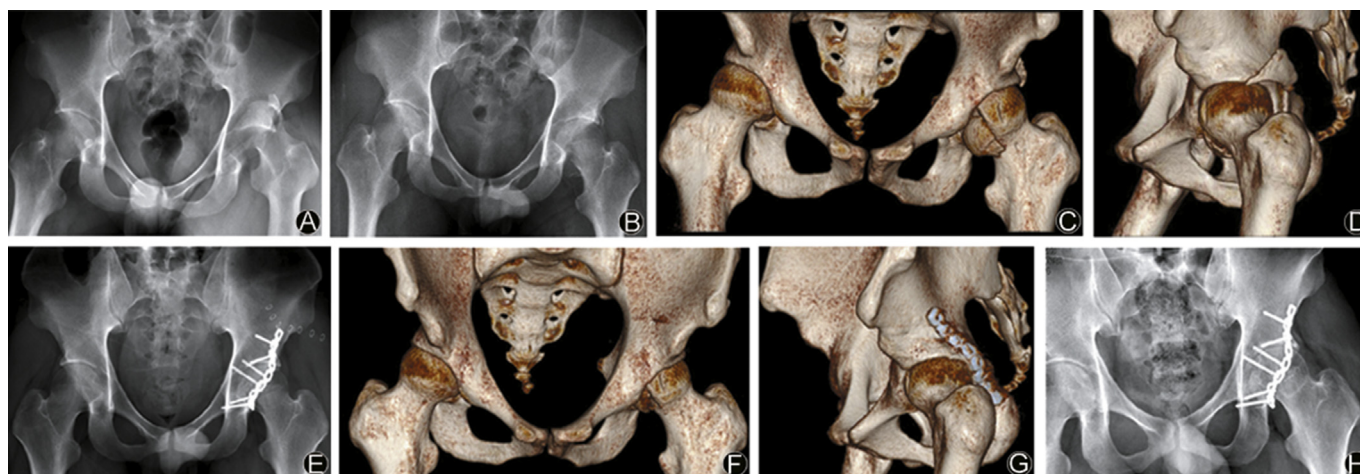


Fig. 1. A 24-year-old male patient with left Pipkin IV type femoral head fracture; A. X-ray film before operation; B. X-ray after manipulative reduction; C D. CT 3-D reconstruction after manipulative reduction; E. X-ray film after operation; F G. CT 3-D reconstruction after operation; H. X-ray film at 1 years after operation.

posterior approaches for the treatment of femoral head fractures and found that the anterior approach caused less blood loss and required a shorter operative time, without increasing the incidence of osteonecrosis. The drawback was the increased incidence of HO. Another disadvantage is the difficulty in exposing the acetabular fracture, making treatment of Pipkin type IV femoral head fractures difficult. The posterior approach can provide good exposure of the acetabular fracture and an opportunity for simultaneous repair of the femoral head and acetabular fractures. An additional benefit is that anterior vascular supply to the femoral head and abductor function can be preserved, even though Stannard et al.²⁵ showed that after a posterior dislocation, a posterior approach to the hip joint causes more damage to the blood supply of the femoral head than an anterior approach. In this study, we adopted the posterior Kocher-Langenbeck approach. Its advantages are as follows: as posterior dislocation of the hip can disrupt the posterior capsule, acetabulum, and surrounding soft tissue, this approach prevents further destruction of the soft tissue of the anterior hip; it preserves the blood supply of the anterior capsule; and it can simultaneously be used to repair the injury to the posterior capsule, which is beneficial for the recovery of the blood supply to the femoral head. In addition, good exposure of the acetabular fracture allows fracture reduction to be accomplished under direct visualization, in order to restore the congruency and stability of the hip. At the same time, surgery should be performed carefully to reduce the stripping and cutting of the gluteal muscles as much as possible, in order to protect the remaining blood supply of the hip joint and reduce the incidence of postoperative avascular necrosis of the femoral head.

Treatment of femoral head fractures

Although open reduction has become the primary means of managing femoral head fracture-dislocation, controversy exists with regard to excision or internal fixation of fracture fragments.^{13,26,27} Earlier studies advocated the excision of all fragments, provided that the fragments constituted less than one-third of the femoral head.^{6,28} However, recent reports have demonstrated that the factors influencing the type of treatment of fracture fragments include fragment size, degree of comminution, and the location of fragments in relation to the weight-bearing surface.¹⁴ In general, when the femoral head fracture block is less than 1 cm or not within the weight-bearing portion

of the head, it can be excised without compromising the outcome, and if a fragment is sufficiently large to allow stable internal fixation or is located in a weight-bearing area, then the fixation should be performed.¹¹ After anatomic reduction has been achieved, temporary fixation should be performed with Kirschner wires. Definitive fracture fixation is subsequently performed with interfragmentary lag screws. Numerous implant options are available, including countersunk interfragmentary 3.5 mm or 2.7 mm lag screws, self-compressing screws, and bioabsorbable screws. The bioabsorbable screws have good tissue compatibility, without any toxic reactions, and do not interfere with radiological imaging, making them conducive to the observation of postoperative fracture reduction and healing. Furthermore, self-degradation of the bioabsorbable screws after surgery allows a second operation to be avoided.²⁹ In our study, four patients underwent excision because the fracture blocks were too small to fix or the fragments were located in the non-weight-bearing area. Seventeen patients were treated with bioabsorbable screws, and according to the actual size of the bone block, two or more bioabsorbable screws were selected during screw fixation. The direction of screw implantation should be perpendicular to the fracture line as much as possible, while minimizing the articular cartilage damage.

Management of acetabular fractures

When a powerful force caused by trauma is applied to the hip joint, the femoral head is believed to exit the acetabulum posteriorly as the head forcibly shears against the acetabular rim, leading to posterior wall fractures of the acetabulum. The most common cause is a dashboard injury. In the treatment of acetabular posterior wall fractures, anatomic reduction is particularly important. The quality of reduction is directly related to postoperative joint function.^{30,31} In a study of 569 patients with acetabular fractures, Letournel et al.³² showed that only 10.2% of patients with anatomic reduction developed post-traumatic arthritis, whereas patients without anatomic reduction showed rates as high as 35.7%. Lukas et al.³³ drew a similar conclusion. After anatomic reduction has been achieved, internal fixation should be performed. Gansslen et al.³⁴ thought that the larger fragment could be fixed with hollow screws, and that when the fracture involves the posterior column, fracture fixation should be performed with a reconstruction plate. When the fracture is

extensive and comminuted and cannot be reduced, the autogenous iliac bone should be used to reconstruct the posterior wall, and fracture fixation should be subsequently performed with reconstructive plates or cannulated screws. In this study, we selected reconstructive plates for internal fixation of the fractures. When fixing the plates, attention should be paid to avoid screw penetration into the joint cavity. If necessary, intraoperative C-arm fluoroscopy can be used to determine the position of the screws and the quality of fracture reduction, to achieve anatomic reduction and solid fixation.

Complications

The main complications included traumatic sciatic nerve injury, post-traumatic osteoarthritis, avascular necrosis of the femoral head, and the formation of HO.^{4,7,8,11,14,17,21,23,28} The incidence of traumatic sciatic nerve injury ranges from 7.0% to 27.0%, and peroneal division of the nerve is most commonly involved.^{11,18} Three of the 21 patients sustained a sciatic nerve injury, with an incidence of 14.2%, and nerve function was partially recovered at the last follow-up. Post-traumatic osteoarthritis is the most common complication of femoral head fracture, and its incidence is directly related to the quality of fracture reduction.^{32,33,35} In our study, three patients developed post-traumatic osteoarthritis, resulting in a lower incidence than the 21.6% reported in the literature.³³

Avascular necrosis of the femoral head and HO have been identified as post-traumatic complications of femoral head fractures and can lead to restrictions in hip function and permanent disability. Guo et al.²⁰ concluded that an anterior approach is one of the risk factors for HO, whereas a posterior approach increases the incidence of avascular necrosis of the femoral head. Droll et al.¹⁴ also thought that an anterior approach increases the incidence of HO, and this potential risk may be related to aggressive muscle stripping from the ilium during the approach. In addition, other risk factors, such as traumatic local muscle damage, head injury, and multiple associated fractures were closely related to the development of HO.

In this study, we adopted the posterior Kocher-Langenbeck approach, which prevents further destruction of the soft tissue of the anterior hip and preserves the blood supply of the anterior capsule; however, surgery should be performed carefully to reduce the stripping and cutting of the gluteal muscles so as to protect the remaining blood supply of the hip joint and reduce the incidence of postoperative avascular necrosis of the femoral head. During follow-up, four patients developed HO, the incidence is 19%. Avascular necrosis of the femoral head occurred in two patients, with no obvious signs and symptoms in one patient, the other patient reported pain and limited motion of the hip in the second postoperative year, and subsequently underwent total hip arthroplasty, with good recovery of limb function after surgery.

Conclusion

Pipkin type IV femoral head fractures include posterior dislocation of the hip, femoral head fractures, and acetabular fractures. Owing to the complexity of the anatomic structure, surgical treatment is particularly difficult and more likely to result in the development of post-traumatic osteoarthritis, avascular necrosis of the femoral head, and other complications. For the treatment of Pipkin type IV femoral head fractures, prompt reduction of the associated hip dislocation, selection of the appropriate surgical approach, anatomic reduction and solid internal fixation of the fractures, and restoration of hip congruency and stability are critical to achieve satisfactory clinical results. The mid-term curative effect

of use of a reconstruction plate and bioabsorbable screws in the treatment of Pipkin type IV femoral head fractures is significant and such treatment can significantly improve the patient's joint function and quality of life.

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