

Original research article

# Closed reduction and minimally invasive screw osteosynthesis of Pipkin femoral head fractures

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## Abstract

**Background:** Femoral posterior hip dislocation with associated femoral head fractures (Pipkin fractures) are rare high-energy injuries. Published treatment modalities involve conservative treatment, head fragment resection, open reduction and internal fixation, and total hip replacement. The experience with mini-invasive screw osteosynthesis of these fractures is the main focus of our study.

**Methods:** Seven Pipkin fractures (five Pipkin II and two Pipkin I) in six patients were treated by closed reduction of hip dislocation, followed by minimal invasive lag screw osteosynthesis. Cancellous screw(s) were inserted from the incision on the lateral hip through the femoral neck to the reduced fracture fragment. In all patients, postoperative CT was performed to check the quality of surgery. Active physiotherapy with immediate toe-touch weight bearing was the routine postoperative protocol. In all patients, radiological and clinical results were evaluated with the Thompson Epstein, Merle d'Aubigne and Postel score, and Harris hip score.

**Results:** All fractures united, and all femoral heads survived. Infectious complications were not observed, and no secondary surgery was needed. After an average follow-up of 18.4 months, the average Merle d'Aubigne and Postel score was 17.7 points, while the mean Harris hip score reached 98.1 points. The majority of patients achieved an excellent Thompson–Epstein clinical and radiological outcome. All patients returned to their original occupation.

**Conclusions:** Mini-invasive screw osteosynthesis can be used for the treatment of Pipkin type I–II femoral head fractures. Successful reduction of hip dislocation and head fracture is necessary for using this technique. Long-term follow-up is necessary to confirm this technique.

**Keywords:** Femoral head fracture; Minimally invasive treatment; Pipkin; Screw osteosynthesis

## Highlights:

- Pipkin type femoral head fracture can be securely stabilized mini-invasively.
- Closed anatomic reduction of femoral head fracture is mandatory.
- Minimal invasive approach is connected with low rate of complications.

## Introduction

Femoral head fractures associated with posterior hip dislocation are relatively rare high-energy injuries. They are mostly caused by traffic accidents, falls from a height, and sports injuries. The optimal treatment of these so called Pipkin injuries is still under debate (Giannoudis et al., 2009; Menger et al., 2021; Scolaro et al., 2017; Tsai et al., 2022). Urgent reduction of hip dislocation should be performed, and the strategy of subsequent treatment depends on fracture patterns and the amount of displacement of the head fragment. The general rule is that greater fragments of Pipkin type I and II should be anatomically reduced and fixed. Nonoperative treatment is relatively rare and is mentioned for cases with perfect fracture fragment reduction after reduction of hip dislocation. The strategy of conservative treatment is not clear; mentioned

methods involve long-term traction, bed rest immobilization, or verticalization (Giannoudis et al., 2009). Anatomic reduction and fixation of displaced fragments provides the best prevention against post-traumatic changes such as heterotopic ossification, avascular necrosis of the femoral head, and secondary osteoarthritis. On the other hand, open reduction is associated with a high rate of osteonecrosis of the head (Gavaskar and Tummala, 2015; Giannoudis et al., 2009; Wang et al., 2019).

Stabilization of a closely reduced femoral head fracture by minimally invasive C-arm guided screws inserted from the lateral border of the femoral neck to the fracture fragment may secure fracture healing and can allow early hip physiotherapy and mobilization of the patient with this type of fracture.

The present work aims to report a new minimal invasive approach and the clinical results of its application in patients with Pipkin fractures.

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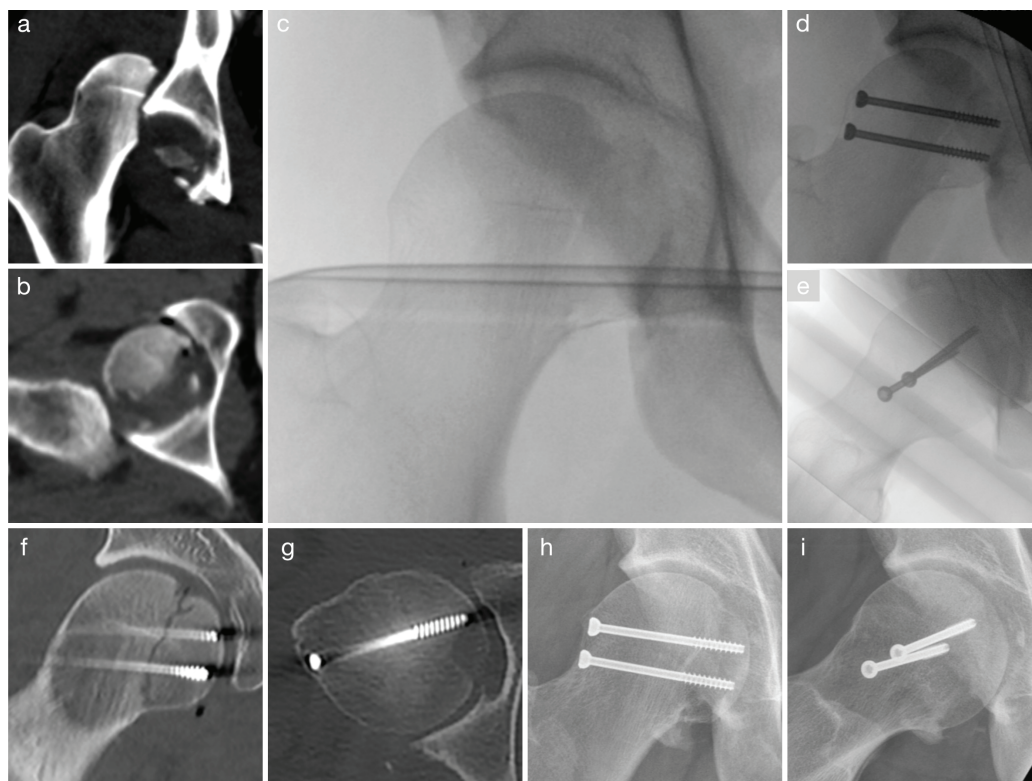
## Materials and methods

Patients with a Pipkin type I–II fracture were enrolled in this study between 2002 and 2021. The inclusion criteria were as follows: (a) an acute posterior hip dislocation, (b) Pipkin type I or II femoral head fracture, (c) successful closed reduction of hip dislocation, (d) reduced femoral head fracture visible on AP and axial view performed by C-arm on OP theatre, (e) minimal invasive lag screw osteosynthesis of femoral head fracture. A total of six patients with seven fractures were enrolled (five males and one female). In three patients, car accidents were the mechanism of injury, two patients sustained motorcycle accidents, and one patient with bilateral injuries fell off road bike.

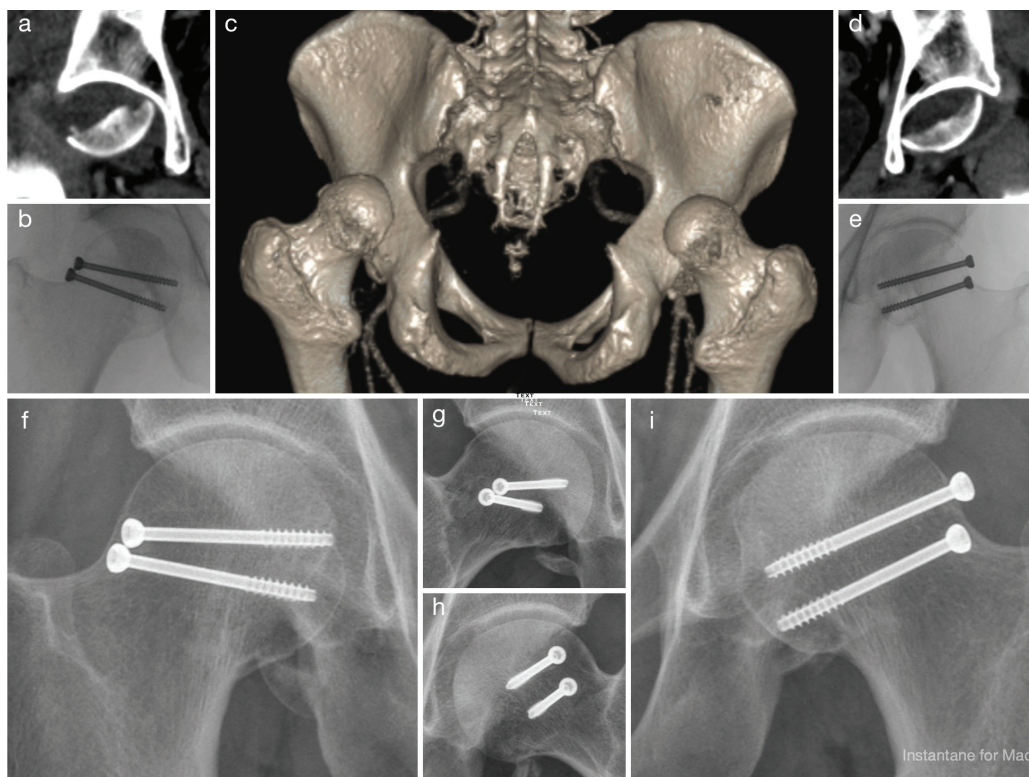
## Interventions

In all patients, CT evaluation of the injured hip was performed. In the majority of them this was part of the CT polytrauma scan. Classification according to the Pipkin classification system was performed. All patients were immediately transported to the operative theatre and placed on the surgical table. Gentle closed reduction of hip dislocation was performed under general anaesthesia in the supine position by the Allis manoeuvre, with hip and knee joints in 90 degree flexion by dorsoventral traction of the femur, combined with gentle rotation manoeuvres of the femur and opposite force on the anterior superior iliac spine. After successful reduction of the hip dislocation were patients placed on a fracture table with traction on the injured extremity, and the opposite extremity on the extremity holder.

The quality of the reduction of the femoral head fracture was carefully analysed in multiple X-ray views on the C-arm. Improvement of reduction quality was made in selective cases by gentle rotations of the femur under C-arm control. When the quality of reduction was rated as anatomic, minimally invasive screw osteosynthesis with screws inserted from the lateral side of the femoral neck was performed. From a small skin incision laterally above the greater trochanter, 1.5 mm Kirschner wires were introduced through the soft tissues to the lateral side of the femoral neck and through the head into the fractured fragment, as perpendicular to the fracture line as possible. In all cases, 2 Kirschner wires were inserted. Countersinking with a 3.5 reamer was performed. After planning the screw length, 4.5 cannulated cancellous screw(s) were sequentially inserted into the fragment as far as possible to achieve the best achievable stability of fixation. In Pipkin type I, one cancellous screw was inserted, and then K wires were removed. In Pipkin type II, two cancellous 4.5 screws were used. The quality of the placement and length of the screws were checked in AP, axial and oblique views of the C-arm. Suture of the skin was made with nonabsorbable sutures. In one case of Pipkin type I injury, reduction quality of the head fragment after hip dislocation reduction was not acceptable. Mini-invasive reduction of the caudad displaced head fragment was then performed by a ball spike inserted from a small incision laterally in the front of the trochanteric area directly to the fragment under C-arm control. Screw fixation was then performed as in other cases. Six of seven surgeries were performed by the same senior surgeon. CT of injured hips, post-reduction X-rays and postoperative CT and X-rays illustrating the techniques described above are presented in Figs 1–3.



**Fig. 1.** Male, 38 years old, Pipkin type II fracture after car accident. (a) CT2D coronary slice trauma, (b) CT2D transversal slice trauma, (c) AP X-ray after reduction of hip dislocation, (d) 4.5 mm cancellous screw osteosynthesis AP view, (e) 4.5 mm cancellous screw osteosynthesis in axial view, (f, g) CT2D coronary and transversal slice postoperative, (h, i) X-ray after one year AP and axial views. After follow-up of 16 months: Merle d'Aubigne Postel score 18 points, HHS 100 points, Thompson–Epstein excellent outcome.



**Fig. 2.** Male, 50 years old, bilateral Pipkin type II fracture after road bike accident. (a) CT2D coronary slice of right hip, (b) finished osteosynthesis with two 4.5 mm cancellous lag screws right side, (c) trauma CT3D reconstruction, (d) CT2D coronary slice of left hip, (e) finished osteosynthesis with two 4.5 mm cancellous lag screws left side, (f, g) AP and axial view right side after one year, (h, i) axial and AP view left side after one year. After follow-up of 16 months: Merle d'Aubigne Postel score 18 points, HHS 100 points, Thompson–Epstein excellent outcome right, good left side.

### Postoperative management

In all patients, postoperative CT was performed to check the quality of the reduction, placement and length of the screws. Early physiotherapy of the hip joint was started immediately after surgery. Immediate full range hip motion exercises were performed, and all patients were allowed toe touch weight-bearing for six weeks, followed by gradually increased weight-bearing during the second six weeks up to full weight bearing. During this time, active exercises for the strengthening of the muscles were performed. Thromboembolic prophylaxis with low-molecular-weight heparin was administered for two weeks.

### Follow-up

All patients were clinically and radiologically evaluated after six weeks, three months, six months, and a minimum of 12 months after surgery. All patients were invited for final clinical and radiological evaluation. At the last follow-up, functional assessment was performed using the Thompson–Epstein (T–E) criteria, modified Merle d'Aubigne and Postel score, and Harris Hip Score.

## Results

There were six patients with seven Pipkin fractures. Five fractures were classified as Pipkin type II, two as Pipkin type I.

In five cases, osteosynthesis of the head was performed immediately after reduction of the hip joint. In two cases (poly-trauma patient and unavailability of the experienced surgeon), osteosynthesis was performed after 53 and 22 hours. In six of seven cases, anatomic reduction of the head fragment was achieved in a closed manner; in one case, mini-invasive reduction with a ball spike was performed.

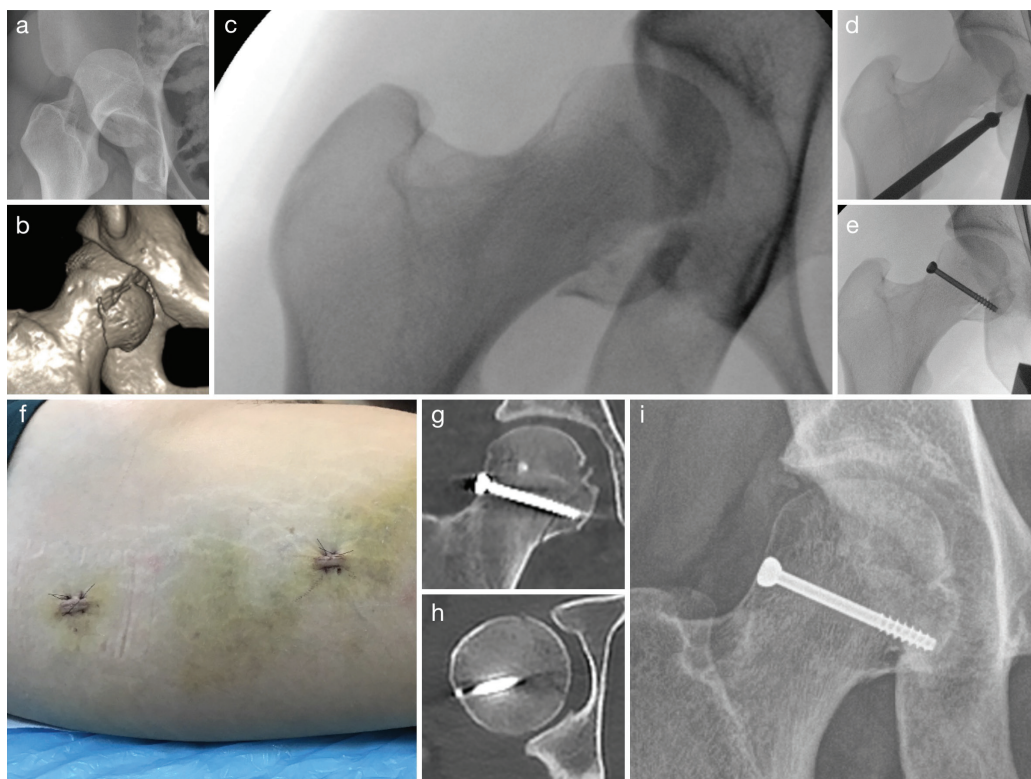
All fractures were on postoperative CT scans, anatomically or near anatomically reduced (residual displacement up to 1 mm) with screws in appropriate direction and length.

All fractures united. No evidence of complete osteonecrosis of the head was evident in the last follow-up radiographs; in one case, partial head necrosis developed. In two cases, heterotopic ossifications with no significant clinical relevance developed. No infectious complications were observed, and no secondary surgery was needed.

All patients were available for final clinical follow-up. The mean follow-up was 18.4 months (range: 16–24 months). The average Harris hip score reached 98.1 points (range: 93–100), and the mean Merle d'Aubigne and Postel score was 17.7 points (range: 17–18). T–E outcome criteria were excellent in four patients, good in two, in one case fair. All patients returned to their original occupation.

Descriptive data of all patients are listed in Table 1.





**Fig. 3.** Female, 19 years, Pipkin type I after motorcycle accident. **(a)** trauma x-ray AP view, **(b)** CT3D reconstruction after reduction of hip dislocation, **(c)** intraoperative X-ray AP view with displacement of head fragment, **(d)** mini-invasive reduction with ball spike, **(e)** finished 4.5 mm cannulated cancellous lag screw osteosynthesis, **(f)** clinical picture after surgery, **(g, h)** postoperative CT2D coronary and transversal slices, **(i)** X-ray AP view after one year. After follow-up of 16 months: Merle d'Aubigne Postel score 17 points, HHS 99 points, Thompson–Epstein excellent outcome.

**Table 1.** Descriptive data of all treated patients

Patient Nr. and sex	Etiology	Age	Pipkin classification	Year of surgery	Size and number of screws	Time from injury to reduction of hip dislocation (min)	Time from hip dislocation reduction to start of surgery	Skin to skin operation time (min)	Follow-up (months)	Merle d'Aubigne Postel score (points)	Harris Hip Score (points)
1 male	motorcycle accident	38	PII	2021	4.5 2×	120	10	50	16	18	100
2 male	road bike 50 km/h	46	PII	2021	4.5 2×	120	30	45	16	18	100
2 male	road bike 50 km/h	46	PII	2021	4.5 2×	125	90	60	16	18	100
3 female	motorcycle accident	19	PI	2021	4.5 1×	110	1320	50	16	17	99
4 female	car accident	27	PI	2020	4.5 1×	60	3180	30	23	17	93
5 male	car accident	37	PII	2002	4.5 2×	100	45	45	24	18	100
6 male	car accident	42	PII	2002	4.5 2×	120	50	52	18	18	95
Mean		36.4				108		47.4	18.4	17.7	98.1

## Discussion

Our study is the first to describe the strategy of minimally invasive screw fixation for femoral head fractures associated with posterior hip dislocation.

Historically, femoral head fractures have been treated conservatively with closed reduction, prolonged bed rest, and inline traction (Butler, 1981; Epstein et al., 1985; Kristensen and Stougaard, 2009). Closed reduction alone (without stabilization of the fractured fragment) increases the rate of posttraumatic arthritis, may result in malunion, and lead to poor Merle d'Aubigne and Postel outcome scores (Leenen and van der Werken, 1990; Tsai et al., 2022). In the review of Giannoudis et al. (2009), only 13% from 54 conservatively treated patients reached an excellent outcome according to Thompson and Epstein criteria, compared to 58% of patients in our group. None of our patients had a poor outcome, compared to 27% in the mentioned review.

### *Pipkin type I*

The strategy of fragment excision was connected with better clinical results than the ORIF strategy in Pipkin Type I fractures (Giannoudis et al. (2009). Similar results were reported in the Tsai et al. (2022) meta-analysis, where fragment excision resulted in the best Thompson–Epstein and Merle d'Aubigne scores. Reduction and internal fixation of a Pipkin type I fracture is recommended if the fragment is larger (Giannoudis et al., 2009; Park et al., 2014; 2015; Tsai et al., 2022). Interestingly, no evidence is available for the method we used; minimal invasive fixation of the reduced head fragment with a lag screw inserted lateromedially through the femoral neck. In our series, both Pipkin type I fractures with larger fragments healed with excellent and good clinical and radiological scores.

### *Pipkin type II*

For Pipkin type II, the majority of surgeons propose anatomic reduction and internal fixation (Aprato et al., 2021; Cao et al., 2019; Droll et al., 2007; Gavaskar and Tummala, 2015; Giannoudis et al., 2009; Giordano et al., 2019; Henle et al., 2007; Ricci et al., 2018; Scolaro et al., 2017; Xu et al., 2020). Clinical results of patients in our group are, on average, better than with other treatment strategies, where the most frequent result is good or fair according to the Thompson–Epstein criteria. Current evidence shows, that after reduction of the hip dislocation the majority of Pipkin type II head fractures are usually not anatomically reduced and demand subsequent open reduction. Our experience is different. Gentle closed reduction technique with an emphasis on the use of inverse forces to forces that leads to dislocation, can play an important role which is similar to the connection between head fragment and connecting soft tissues, especially the capitis femoris ligament. Although Henle et al. reported acceptable quality of reduction in only 1 case out of 12 (Henle et al., 2007), the reduction success rate could be higher in the proper way of performing reduction. In our institution, from six cases of Pipkin fractures in the last 3 years, four were reduced anatomically in a closed manner. The technique of hip dislocation reduction can play an important role in fracture reduction quality. Connection of the head fragment with the acetabulum through the capitis ligament influences the position of the head fragment in the joint. Evidence for the influence of different reduction techniques on fracture reduction quality is poor.

Although conservative treatment for Pipkin type II fracture is mentioned in reviews (Giannoudis et al., 2009), evi-

dence regarding this type of treatment is rare, and the optimal strategy in cases with anatomically reduced head fracture is not clear.

Our technique combines the advantage of a non-invasive approach with stabilization of the fracture. The combination of enhanced stability of the fracture fragment achieved by screw fixation with no additional damage to the soft tissues can be advantageous for securing vitality of the femoral head. Another advantage of our strategy is no additional damage to the cartilage of the fragment, which in the open approach and using countersunk screws is present.

The direction and starting point of the screw(s) in the area of the lateral femoral neck could be questionable. The blood supply of the femoral head has been studied earlier in cadaveric studies. The ascending branch of the medial femoral circumflex artery is placed on the posterior part of the femoral neck, and terminal subsynovial branches are located on the postero-superior aspect of the neck of the femur and penetrate the bone 2 to 4 mm lateral to the bone-cartilage junction (Gautier et al., 2000).

The course of the upper Weitbrecht retinacula and the distribution of nutrient foramina have been analysed in MRI and cadaveric studies in recent years (Gavaskar and Tummala, 2015; Rego et al., 2017). The majority of nutrient foramina are localized in the upper part of the neck ventrocranially. Blood supply of the femoral head could be traumatized by the drill and screw if the starting point on the lateral neck is too ventrocranially, or if there are too many repetitive attempts to place the guiding K wire, with subsequent partial head necrosis. This complication can be prevented by placing the starting point more (not too) posteriorly if the course of the fracture line allows this approach. Despite this fact, we did not observe femoral head necrosis.

A strength of our study is that it provides the very first description of a novel technique of osteosynthesis of femoral head fractures, combining stabilization of the head fragment with a mini-invasive approach. Second, our clinical results are excellent and have no major complications. Two of our patients were treated more than 19 years ago with no secondary surgery. Five patients were treated in the last three years.

A limitation of our study is the relatively short follow-up. In 4 of 7 cases this was only 16 months, but avascular head necrosis can develop later than after one year, up to 3–5 years after the procedure. Another shortcoming is the small number of cases, which does not allow appropriate statistical analysis and comparison with other techniques.

## Conclusions

Minimally invasive screw osteosynthesis can be used for the treatment of Pipkin type I and II femoral head fractures. Successful closed reduction of hip dislocation and femoral head fracture is necessary for using this fixation technique.

### *Ethical approval*

In view of the retrospective nature of the study, ethical approval was waived by the local Ethics Committee of České Budějovice Hospital, and all the performed procedures were part of the routine care.

### *Informed consent*

Every patient signed informed consent for operative treatment of femoral head fracture.

## Conflict of interests

The authors have no conflict of interests to declare.

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