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UP-TO DATE REVIEW AND CASE REPORT

Silent iatrogenic pseudoaneurysm after intertrochanteric fracture fixation with proximal femoral nailing and cerclage wiring: case report and review of literature

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Abstract

Pseudoaneurysm is a rare complication after intertrochanteric fracture fixation. Herein, we present a rare case of late development of a pseudoaneurysm with silent clinical symptoms. The case was a 91-year-old woman treated with proximal femoral nailing and cerclage wiring. Postoperatively, the patient was able to ambulate with a walker without abnormal symptoms. During the follow-ups, the radiographic images showed progressive cortical scalloping on the medial femoral shaft. Ultrasonography revealed a yin-yang sign, and a CT scan confirmed a pseudoaneurysm at the profunda femoris artery (PFA). In this case, many possible causes of pseudoaneurysm were hypothesized. We showed that the excessive displaced, long spiral pattern of an intertrochanteric fracture, which was irreducible by a closed technique, is the risk of a PFA injury. An atherosclerotic vessel was seen in preoperative radiography, indicating poor vessel elasticity which may be a risk of vessel tear during fracture reduction using multiple reduction instruments in excessive displaced fracture. Moreover, over-penetration when drilling should not be overlooked. We also discuss the predisposing factors, surgical techniques which may lead to this type of PFA injury and summarize the literature of pseudoaneurysms related to intertrochanteric fracture fixation.

Keywords Pseudoaneurysm · Vascular injury · Intertrochanteric fracture · Hip fracture · Proximal femoral nail · Cerclage wiring

Introduction

Intertrochanteric fractures are common, for which the standard treatment is internal fixation. Vascular injury related to internal fixation of an intertrochanteric fracture is rare but serious and requires specific treatment. The incidence of vascular injury after internal fixation of a proximal femoral fracture was reported at 0.49% in one review, of which pseudoaneurysm is the most common type accounting for 67.03% of cases [6]. Untreated pseudoaneurysms can lead to morbidity or serious complications such as infected hematoma, delayed fracture healing, thigh compartment syndrome, or deep vein thrombosis [70]. Rupture of a pseudoaneurysm leads to massive haemorrhage.

Herein we present a case of late development of a pseudoaneurysm after intramedullary nail fixation with cerclage wiring augmentation. Postoperatively, the patient had no abnormal symptoms. Cortical scalloping seen in routine fracture follow-up plain radiography was the only clue for further investigation. The ultrasonography and computed tomography angiography (CTA) were carried out to confirm the diagnosis of pseudoaneurysm of PFA. Pseudoaneurysm was eventually treated by coil embolization. In this case, many possible causes of pseudoaneurysm were hypothesized. An atherosclerotic vessel was seen in preoperative radiography, indicating poor vessel elasticity which may be a risk of vessel tear during fracture reduction using multiple reduction instruments in excessive displaced fracture. Moreover, over-penetration when drilling should not be overlooked.

The patient consented to the publication of this case report. The paper was approved by the Ethics Committee of Faculty of Medicine, Prince of Songkla University.

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Case presentation

A 91-year-old woman presented with an intertrochanteric fracture of the right femur (AO classification; 31-A1). Initial radiographic images showed a long spiral trochanteric fracture extending to the subtrochanteric area (Fig. 1). No preoperative signs or symptoms of vascular injury, such as swelling or a pulsatile mass, were seen. The preoperative haematocrit level was 26.7% (normal range 37–47%), and haemoglobin was 8.3 g/dL (normal range 11–15 g/dL). Enoxaparin 20 mg was injected subcutaneously for deep vein thrombosis prophylaxis and stopped 24 h prior to the surgery.

For the operation, the patient was placed in the supine left hemi-lithotomy position on the fracture table. A closed fracture reduction was attempted but failed to achieve anatomical alignment (Fig. 2A), so the reduction was converted to an open reduction. An incision was made on the lateral aspect of the thigh at the lesser trochanteric level and the fracture was reduced and maintained by a colinear clamp (Fig. 2B). Kirschner wires were then inserted for temporary fixation. Cerclage wiring was done at the subtrochanteric level using a wire passer to maintain the anatomical reduction (Fig. 2C). Radiographic fluoroscopy was performed to check the alignment. A proximal femoral nail antirotation (PFNA, Synthes, 200 mm in length) was inserted. No intraoperative complications were noted. Postoperatively, routine deep vein thrombosis prophylactic protocol was applied including pneumatic calf compression and early ambulation within a few days. No sign and symptom of deep vein thrombosis was found. The patient could ambulate with a walker after a few days neither thigh pain nor swelling. Her haematocrit was normal.

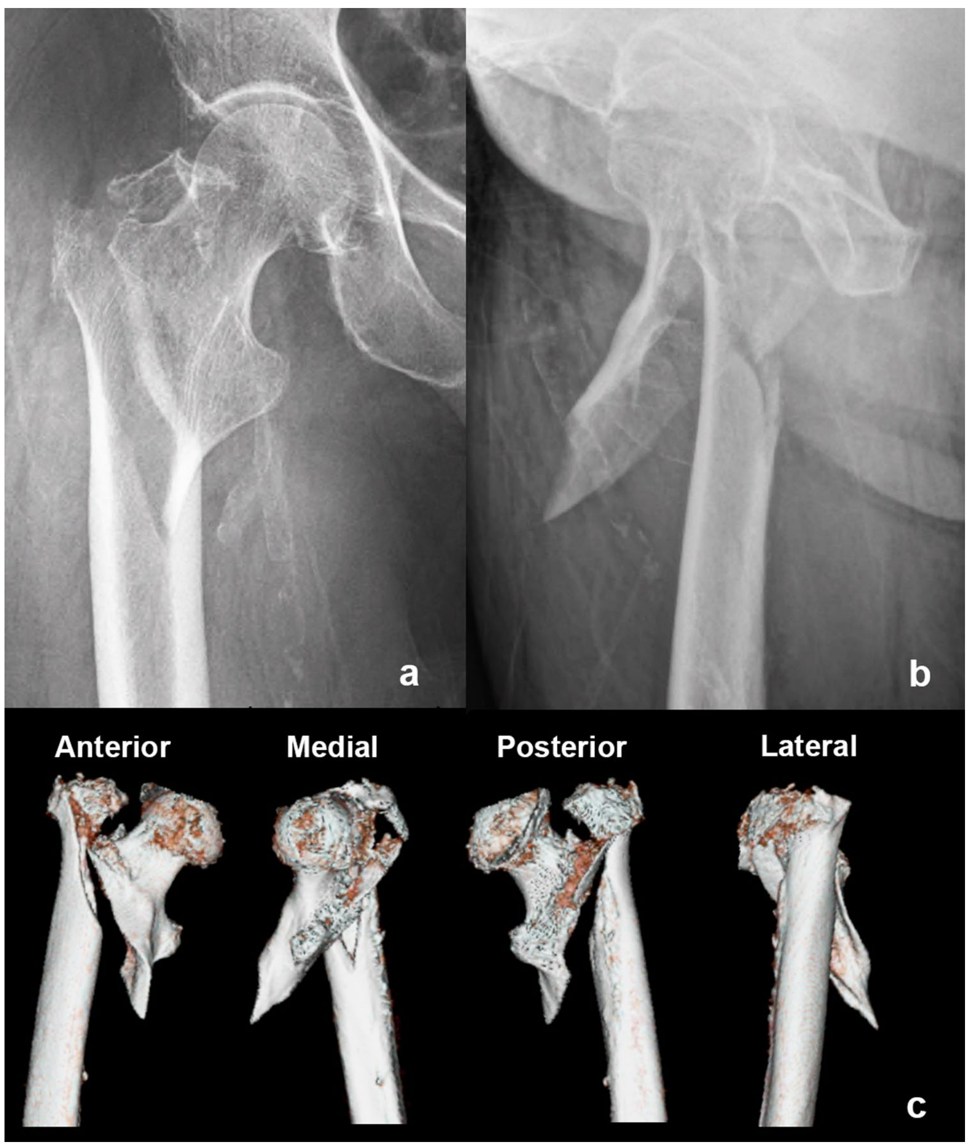


Fig. 1 Intertrochanteric fractures with a long spiral extending to the subtrochanteric area. This pattern poses a risk of profunda femoris artery injury

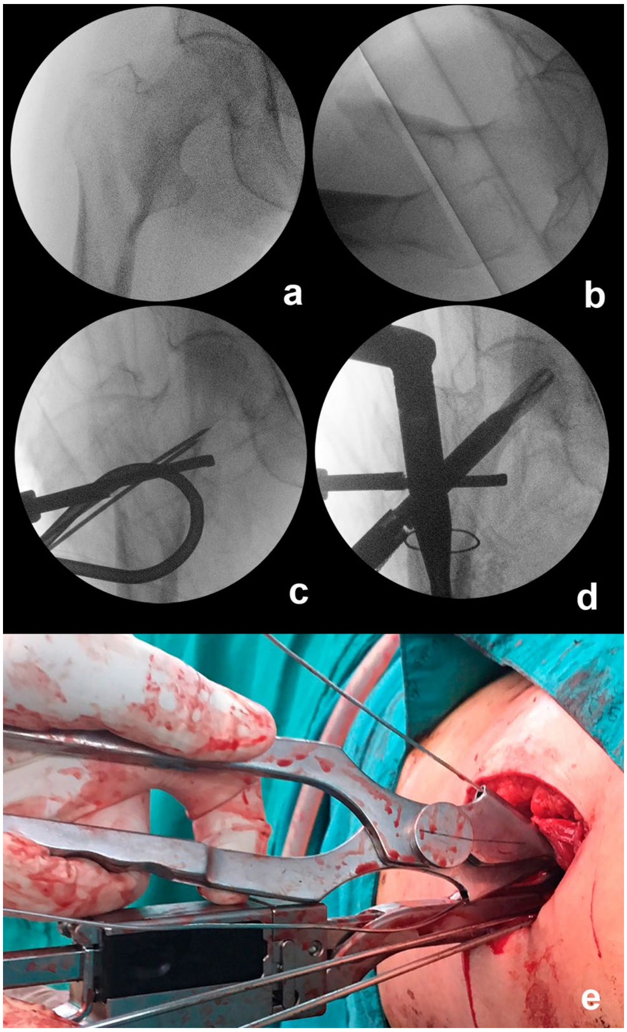


Fig. 2 Intraoperative findings: the fracture was irreducible by a closed technique on the fracture table (**a**, **b**). The fracture was reduced properly by a collinear clamp and cerclage wiring using a wire passer (**c**). Proximal femoral nail antirotation was inserted without immediate complications (**d**). Application of various instruments may stretch the atherosclerotic profunda femoris artery (**e**)

Postoperative radiography demonstrated a good position of the implant. No soft tissue hypodensity was seen on the medial aspect at the subtrochanteric level.

At the 3-month follow-up, the patient was able to walk with a walker without thigh pain. There was no palpable mass, and the distal pulse can be palpated. However, a plain radiograph showed obvious bony scalloping on the medial cortex of the right femur. Calcification was seen at the surrounding soft tissue density mass (Fig. 3). Ultrasonography demonstrated a well-defined heterogenous hypo- and hyperechoic lesion with a yin-yang sign on the colour flow (Fig. 4A). CT angiography revealed a partially thrombosed pseudoaneurysm on the perforating branch of the right profunda femoris artery (Fig. 4B, C). The thrombosed mass compressed medial cortex of proximal femoral shaft causing bone scalloping. The distal locking screw did not appear to be excessively long (Fig. 5). Her haematocrit (32.2%) and haemoglobin (9.9 g/dL) were normal. Coil embolization was performed without complications. At 1-year follow-up, the fracture was healed.

Discussion

Vascular injury related to internal fixation can be detected in the early or late follow-ups. A patient with a vascular rupture or tear may present with hard signs such as haemorrhage. Thigh pain and swelling accompanying decreased haematocrit are commonly found. A pulsatile mass can be found if the mass is in the superficial layer. A pseudoaneurysm can develop soon or longer following the surgery and can be asymptomatic. An enlarged pseudoaneurysm can cause thrombosis presenting with swelling and pain.

The profunda femoris artery (PFA) is the most common structure at risk of arterial injury in a proximal femoral fracture [6]. The PFA branches at the posterolateral aspect of the femoral artery. At the trochanteric level, the PFA is separated from the femoral bone by the rectus femoris, iliopsoas and pectineus muscles. At the proximal one-third of the femoral shaft, the PFA courses between the adductor longus and adductor brevis muscles and provides three perforating arteries to supply posterior thigh muscles. At this level, the PFA is close to the medial to posteromedial aspect of the femur. Therefore, the PFA is vulnerable to injury during any orthopaedic procedure at the subtrochanteric to the proximal one-third of the shaft [59, 69]. During a fracture reduction using a fracture table, traction and internal rotation are applied to the affected leg, and the perineal pole may press against the femoral shaft, pushing the PFA closer to the shaft [66]. A large perineal pole may increase the risk of PFA injury.

Pseudoaneurysms are difficult to detect, especially when the patient has no suggestive signs or and symptoms. Postoperative findings such as unexplained/disproportionate haematocrit reduction may help the surgeon to detect this subtle problem. In the early phases, plain radiographs may not show abnormal findings. Late radiographic signs during follow-up plain radiographs, such as bony scalloping of the femoral cortex indicating cortical resorption from external mass compression, are uncommon [44, 71]. In this report, we had early detection of bone scalloping of the femoral

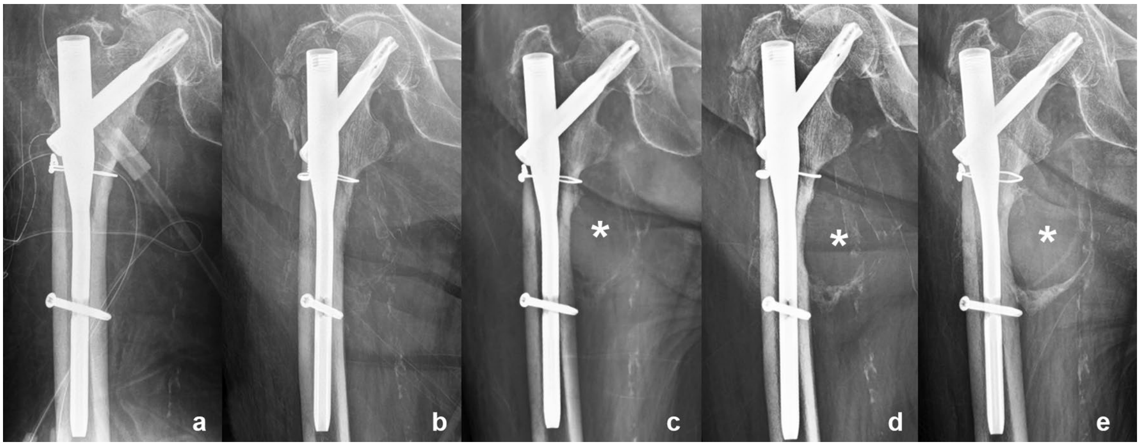
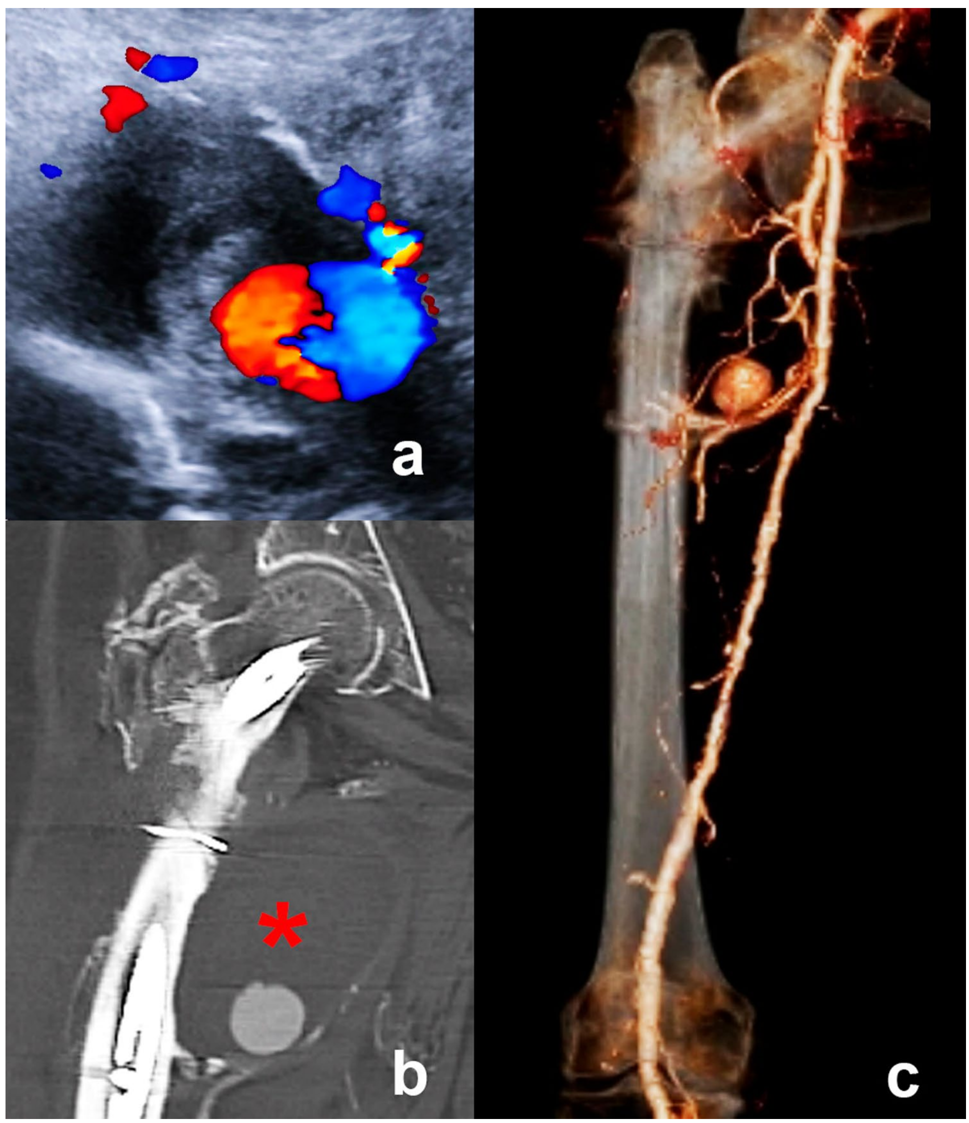


Fig. 3 Follow-up plain radiographic images: at immediate postoperative day 1 (**a**), 1 month (**b**), 2 months (**c**), 3 months (**d**) and 4 months (**e**). Cortical scalloping (asterisk) is seen at 3 months postoperatively

Fig. 4 Ultrasonography and CT angiography. **a** Ultrasonography showing the yin-yang sign. **b**, **c** CTA illustrating a contrast-filled sac with a low-attenuation area (asterisk)



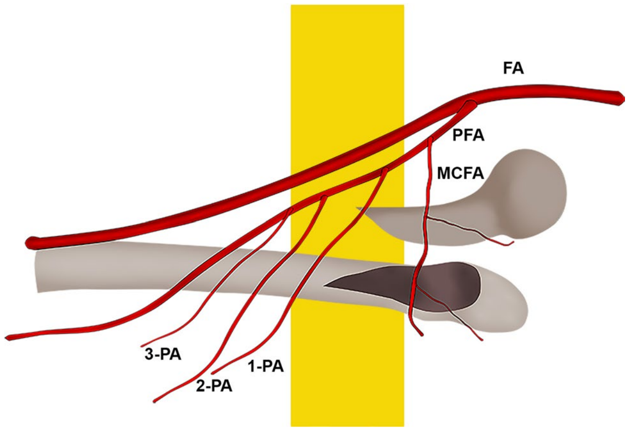


Fig. 5 Profunda femoris artery (PFA) injury in a long spiral fracture of the intertrochanter with excessive posterior displacement of the femoral shaft. PFA could displace and be close to the fracture site. Fracture manipulation during cerclage wiring in this type of subtrochanteric fracture may involve a risk of PFA injury. The yellow highlighted area indicates the danger zone in which there is a risk of potential injury to the 1st and 2nd branches of the perforator artery (PA)

shaft at three months follow-up before the pseudoaneurysm may become symptomatic such as thigh swelling due to more enlargement of pseudoaneurysm.

In pseudoaneurysm cases, colour Doppler ultrasonography usually shows the yin-yang sign which demonstrates swirling of blood flow in the pseudoaneurysm. An MRI also reveals a cystic mass with multistage blood components representing blood leakage into the pseudoaneurysm.

Fixation-related vascular injuries can be caused by various factors. An atherosclerotic vessel, seen in a preoperative radiographic image, is an important predisposing factor for vascular injury in elderly patients. Calcification in a vessel drastically decreases vascular elasticity. Manipulation of brittle atherosclerotic vessels during fracture reduction may result in vascular injury [57]. Therefore, deeply inserting retractors to elevate a vessel from the bone should be avoided, or done with caution [23]. In our case, an atherosclerotic PFA was found on the preoperative image. The PFA was also running closely to the spike of a proximal fragment. Therefore, the first hypothesis for the PFA injury in this case was that it may have been related to soft tissue manipulation such as traction or multiple tool application through the limited soft tissue window (Fig. 2).

Some fracture configurations of an intertrochanteric fracture, such as a displaced lesser trochanteric (LT) fragment, can directly damage adjacent vessels [5, 41, 57, 62]. A displaced LT fragment is the most common cause of PFA injury. The LT-related pseudoaneurysm may have acute onset symptoms [31]. Delayed presentation may be associated with further LT displacement during rehabilitation [21]. The treatment sometimes requires LT excision [52].

Long spiral or posteromedial extension of a femoral fragment can directly damage surrounding vessels. To reduce this fracture type, cerclage wiring is a useful technique to improve stability and assist reduction without interruption of fracture healing [4, 24, 26, 35]. Cerclage wiring may pose a risk of vascular injury by strangulation. However, no reports of PFA injury or injury to its branches have been revealed regarding cerclage wiring [34].

Excessive displacement of the femoral shaft, such as posterior translation, may be a predisposing factor for vascular injury (Fig. 2B). A perforator of the PFA may proximally migrate into the fracture zone which increases the risk of injury during fracture manipulation (Fig. 5). Moreover, various reduction tools may be applied to assist fracture reduction making the surrounding vessels more vulnerable.

Another cause of PFA injury is over-penetration when drilling for a dynamic hip screw side plate and proximal femoral nails. Recently, Jaipurwala et al. [28] analysed CTAs of lower extremities showing the distance of the PFA to the femoral shaft. The mean distances of the first perforator to the shaft were 112.6 and 123.4 mm in women and men, respectively. The mean distances of the second perforator were 159.7 and 178.9 mm, respectively. Over-penetration drilling may be prevented by conscious concentration to the change of the drilling sound. An over-length screw may cause late development of a PFA injury by irritation of an over-length screw tip on the vessels [20, 78]. In this case, a CT scan showed no protrusion of any screw tip.

To understand the clinical presentation of a pseudoaneurysm after intertrochanteric fracture fixation, case reports of pseudoaneurysm related to intertrochanteric fixation were searched in PubMed and the Scopus database during 2000–2022, and 74 cases were found. The fracture characteristics, onset, causes and symptoms were recorded (Table 1). The most common fracture type classified by AO classification type was 31A2 (59.46%). The LT was commonly involved. Interestingly, in 68.18% of all intertrochanteric fracture with LT fractures, an LT fragment was the cause of the PFA injury. Atherosclerotic vessels were seen in radiographic images in approximately 9.46% of the cases. Most patients presented with swelling (85.14%) and/or pain (70.27%). Palpable masses were not common (24.32%). Only 1.35% of the cases were asymptomatic. Thus, our case was very rare as only a radiographic sign was noted without clinical signs or symptoms. Patients with a pseudoaneurysm may have an acute (< 1 week; 29.73%), subacute (1–4 weeks; 31.08%) or late (> 4 weeks; 36.49%) presentation. Direct injury from an LT fragment spike

Table 1 Pseudoaneurysms of the profunda femoris artery after intertrochanteric fracture fixation during 2000–2022 case by case

Author(s) (year)	Fracture (AO-31)	Age	Fracture specific character		Ath-erosclerotic vessels in X-ray	Onset (months)	Implant	Symptom					Cause	Treatment	Late/associated complication
	A1-Sim A2-LWI A3-RO		displaced femoral shaft	LTD				Pain	Mass	Swelling	Anaemic sign	Other			
Jiya et al. [30]	A1	84	NM	No	No	2 days	DHS (115 mm)	✓	–	✓	–	–	Drill	CE	–
Strom et al. [68]	A1	97	NM	✓	No	6 weeks	Gamma nail	✓	✓ (Pulsatile)	✓	–	Unpalpable peripheral pulse	Drill?, screw?	CE	–
Entwisle et al. [17]	NM	69	NM	NM	NM	24 h	DHS	✓	–	✓	–	–	Drill	CE	–
Entwisle et al. [17]	NM	82	NM	NM	NM	5 days	DHS	–	–	✓	✓	–	Drill	CE	–
Lopes et al. [46]	A2	71	No	✓	No	18 days	DHS	✓	–	✓	✓ (↓Hct)	–	Drill	Ligation, repair	
Bernstein et al. [7]	A2	92	–	✓	–	21 days	GN Gliding nail	–	–	✓	✓ (↓Hct)	–	LT spike	Resection	–
Chong et al. [11]	A3	25	NM	NM	NM	2	IM nail and fasciotomy	–	–	✓	✓ (Pale ↓Hct)	Faint distal pulse, bleeding	NM	CE	–
Dillon et al. [15]	A2	50	✓	✓	No	7	DHS	✓	✓	–	NM	Femoral neuropathy	Screw	Repair	–
Maheshwari et al. [47]	A2	78	✓	✓	No	3	DHS	–	✓	✓	✓(↓Hct)	–	LT spike	CE	–
Tai et al. [70]	A2	83	NM	✓	No	23 days	DHS	✓	–	✓	✓(↓Hct)	Hematoma, DVT, failed DHS	LT spike	Repair	–
Alwhouhayb and Howard [2]	A2	82	NM	✓	NM	6 days	DHS	✓	–	✓	✓(↓Hct)	Haemorrhage	LT spike	Resection	–
Anderson et al. [3]	A3	83	✓	No	NM	2	DHS	✓	✓(Pulsatile)	–	NM	–	Shaft displacement	CE	–
Karasugi et al. [31]	A2	74	✓	✓	NM	1 day	Gamma nail	✓	✓	✓	✓(↓Hct)	–	LT spike Used hook/elevator	Embolization	–
Laohapoonsungsee et al. [42]	NM	71	NM	NM	NM	24	Gamma nail	✓	✓	✓	–	–	Screw	Embolization, resection	–

Table 1 (continued)

Author(s) (year)	Fracture (AO-31)	Age	Fracture specific character		Ath-erosclerotic vessels in X-ray	Onset (months)	Implant	Symptom					Cause	Treatment	Late/associ-ated compli-cation
	A1-Sim A2-LWI A3-RO		displaced femoral shaft	LTD				Pain	Mass	Swelling	Anaemic sign	Other			
Laohapoon-sungsee et al. [42]	A2	78	No	✓	No	1	DHS	✓	✓	✓	NM	–	Screw	Emboliza-tion	–
Tzeng et al. [72]	NM	44	NM	NM	NM	6 days	DHS	✓	–	✓	NM	–	Screw	CE	–
Chandra-senan et al. [10]	NM	94	NM	NM	NM	9 days	DHS	–	–	✓	✓(↓Hct)	–	Drill	CE	–
Kickuth et al. [32]	NM	39	NM	NM	NM	1 day	Proximal femoral nail	NM	NM	NM	✓(↓Hct)	NM	Shaft displace-ment	CE	–
Kikuzato et al. [33]	A1	81	No	No	No	7 day	DHS	–	–	✓	✓(↓Hct)	Shock	Screw	CE	–
Cowley et al. [12]	A2	76	✓	✓	✓	1.5	DHS	✓	–	✓	✓(↓Hct)	Bleeding	NM	CE	–
Fohlen et al. [18]	A1	85	No	No	No	hours	Gamma nail	✓	–	✓	✓(↓Hct)	Shock	Drill, screw	CE	–
Ritchie et al. [63]	A2	74	No	✓	No	NM	DHS	–	–	✓	–	–	LT spike	Ligation	–
Dorrucci et al. [16]	NM	40	NM	NM	NM	20 days	DHS	✓	–	✓	✓(↓Hct)	–	Bone frag-ment	Stent	–
Popovic and Stankovic [58]	A2	59	NM	✓	NM	1	DHS	✓	–	✓	–	–	LT spike	Repair	–
Rajaesparan et al. [60]	A1	81	NM	No	NM	1	Intramedul-lary hip screw	–	✓	✓	✓(↓Hct)	–	Drill	CE	–
Shah et al. [65]	A2	86	NM	✓	NM	5 weeks	DHS	✓	–	✓	–	–	Drill	Thrombin injection	DVT
Vaidyalin-gasharma et al. [73]	A2	86	No	✓	No	2	DHS	–	–	✓	✓(↓Hct)	Claudica-tion	LT spike?, drill?	CE	–
Wells and Mahomed [75]	A2	79	✓	✓	✓	8 days	Proximal femoral nail	–	–	✓	✓(↓Hct)	–	LT spike	Repair	DVT

Table 1 (continued)

Author(s) (year)	Fracture (AO-31)	Age	Fracture specific character		Ath-erosclerotic vessels in X-ray	Onset (months)	Implant	Symptom					Cause	Treatment	Late/associated complication
	A1-Sim A2-LWI A3-RO		displaced femoral shaft	LTD				Pain	Mass	Swelling	Anaemic sign	Other			
Giannakopoulos et al. [19]	A2	80	No	✓	NM	11 days	Gamma nail	✓	✓	✓	✓(↓Hct)	–	LT spike	CE	–
Kizilates et al. [39]	A2	87	No	✓	No	3 weeks	Gamma nail	✓	✓(Pulsatile)	–	✓(↓Hct)	–	LT spike	Repair	–
Kizilates et al. [39]	A2	86	No	✓	No	12 days	Gamma nail	–	✓	–	✓(↓Hct)	–	LT spike	Stent	–
Lohmann et al. [45]	A2	82	No	✓	No	3 weeks	Gamma nail	✓	–	✓	✓(↓Hct)	–	LT spike	Repair	–
Chan et al. [9]	A1	83	No	No	No	23 days	DHS	–	–	✓	✓(↓Hct)	–	Drill?, screw?	Resection	–
Hamoui et al. [22]	A1	57	No	No	No	2	DHS	–	–	✓	–	–	Drill	CE	–
Molthof et al. [49]	A2	63	No	✓	No	9 days	Gamma nail	✓	–	✓	✓(↓Hct)	–	LT spike	Resection	–
Molthof et al. [49]	A2	75	No	✓	No	4 weeks	Proximal femoral nail	✓	–	✓	✓(↓Hct)	–	LT spike	CE	–
Papageorgiou et al. [54]	A2	80	No	✓	No	3 days	DHS	✓	–	✓	✓(↓Hct)	–	Drill?, clamp?	CE	–
Helleman et al. [25]	A2	82	NM	✓	NM	5 days	Gamma nail	✓	–	✓	–	–	LT spike	Resection	
Kinugawa et al. [38]	A1	80	No	No	NM	8 days	DHS	✓	–	✓	✓(↓Hct)	Shock	Drill	CE	–
Li et al. [43]	A2	88	NM	✓	✓	2 weeks	Proximal femoral nail	✓	–	✓	✓(↓Hct)	Weakness Dizziness	Bone spike	CE	–
Craxford et al. [13]	A1	82	No	✓	No	1 week	DHS	–	–	–	✓(↓Hct)	Tachycardia Bruise	LT spike?	CE	–
Singh et al. [67]	A2	65	No	✓	No	3 days	DHS	–	–	✓	✓(↓Hct)	–	LT spike?, screw?	CE	–
Patelis et al. [55]	NM	92	NM	NM	NM	2	DHS	✓	–	–	✓(↓Hct)	Fever	Screw	CE	–

Table 1 (continued)

Author(s) (year)	Fracture (AO-31)	Age	Fracture specific character		Ath-erosclerotic vessels in X-ray	Onset (months)	Implant	Symptom					Cause	Treatment	Late/associ-ated compli-cation
	A1-Sim A2-LWI A3-RO		displaced femoral shaft	LTD				Pain	Mass	Swelling	Anaemic sign	Other			
Rana et al. [61]	A2	48	✓	✓	No	2 months	DHS	✓	–	✓	✓(↓Hct)	–	LT spike	CE	–
Regus and Lang [62]	A2	85	NM	✓	✓	3 weeks	Gamma nail	–	✓(Pul-satile)	–	–	–	LT spike, calcified PFA	Resection, vein patch	–
de Raaff et al. [14]	A2	78	NM	✓	No	5	Gamma nail	✓	–	✓	–	–	LT spike	Thrombin injection, stent	CHF, death
Liu et al. (2016)	A2	87	NM	✓	No	0 day	Gamma nail	✓	–	✓	NM	–	Drill?, screw?	CE	–
Roy et al. [64]	A2	55	NM	✓	No	4 days	DHS	✓	–	✓	✓(↓Hct)	–	Drill	CE	–
Yoon et al. [76]	A1	79	No	No	No	1 day	Proximal femoral nail	✓	–	✓	✓(↓Hct)	Hypoten-sion	Drill	CE	–
Abed et al. [1]	A2	49	✓	✓	No	18	DHS	–	✓(Pul-satile)	–	✓(↓Hct)	Limb external rotation Nonunion	Drill?, screw?	Ligation, debride-ment, proxiaml femoral plate	Infection
Gong et al. [20]	A2	50	NM	No	NM	1	PFNA2	✓	–	✓	–	–	Screw	Debride-ment, resection, ligation	–
Gong et al. [20]	A1	81	No	No	No	0 day	PFNA2	✓	–	✓	✓(↓Hct)	–	Drill	No	–
Kim et al. [36]	A2	85	No	✓	No	12 h	PFNA2	✓	–	✓	✓(↓Hct)	–	Guide wire	CE	–
Piolanti et al. [57]	A2	90	No	✓	No	16 days	Intramedul-lary nail	✓	–	✓	✓(↓Hct)	–	LT spike	Stent	–
Toyota et al. [71]	A2	76	NM	✓	✓	4	Intramedul-lary nail	✓	–	✓	✓(↓Hct)	Bone scal-loping	Screw	Resection, ligation	–
Kinoshita et al. [37]	A2	80	NM	✓	No	1 day	Intramedul-lary nail	–	–	–	✓(↓Hct)	Warm Bleeding	Drill	CE	–

Table 1 (continued)

Author(s) (year)	Fracture (AO-31)	Age	Fracture specific character		Ath-erosclerotic vessels in X-ray	Onset (months)	Implant	Symptom					Cause	Treatment	Late/associ-ated compli-cation
	A1-Sim A2-LWI A3-RO		displaced femoral shaft	LTD				Pain	Mass	Swelling	Anaemic sign	Other			
Mayurasa-korn et al. [48]	A2	70	✓	✓	No	6 days	Failed PFNA to angle blade plate	✓	Pulsatile	✓	✓(↓Hct)	–	LT spike	Ligation	–
Nadal Bares et al. [50]	A2	87	No	✓	No	15 days	Gamma nail	✓	–	✓	✓(↓Hct)	Hypoten-sion	LT spike	CE	–
Pandey et al. [53]	A1	85	No	No	No	6	DHS	–	–	✓	–	–	Approach?, screw ?	CE	–
Vande Voorde et al. [74]	A2	78	✓	No	No	8	PFNA	–	–	✓	–	–	Screw	Suture	–
Zhang et al. [77]	A2	80	NM	✓	NM	2 days	PFNA	✓	–	✓	–	–	LT spike	CE	–
Zhang et al. [77]	NM	43	NM	NM	No	1 day	Proximal femoral plate	✓	–	✓	–	–	Drill	CE	–
Jain et al. [27]	A1	79	No	No	✓	2 days	Proximal femoral nail	✓	–	✓	✓(↓Hct)	–	Drill?, trac-tion?	Thrombin emboliza-tion	–
Labronici et al. [41]	A2	87	✓	✓	NM	23 days	DHS	✓	–	✓	✓(↓Hct)	Hypoten-sion Pallor	LT spike	Stent (not improve)	6 months, recur pain LT removal PFA repair
Lidder et al. [44]	A1	72	NM	No	No	15	DHS	✓	✓	✓	NM	Bone scal-loping	Screw	CE	–
Nakajima et al. [51]	A1	90	NM	No	NM	NM	Proximal femoral nail	✓	–	✓	NM	–	Screw?	Stent	–
Nossa et al. [52]	A2	61	NM	✓	NM	8 days	Proximal femoral nail	✓	–	✓	NM	–	LT spike	Stent	Re–surgery LT cause stent dis-placement LT removal

Table 1 (continued)

Author(s) (year)	Fracture (AO-31)	Age	Fracture specific character		Ath-erosclerotic vessels in X-ray	Onset (months)	Implant	Symptom					Cause	Treatment	Late/associ-ated compli-cation
	A1-Sim A2-LWI A3-RO		displaced femoral shaft	LTD				Pain	Mass	Swelling	Anaemic sign	Other			
Zheng and Lin [78]	NM	83	NM	NM	NM	24	DHS	✓	✓(Pul-satile)	✓	–	Pallor Poikilother-mia (SFA com-pression)	Screw	Resection	–
Bowden et al. [8]	A2	90	✓	✓	✓	33 days	Proximal femoral nail	✓	–	✓	✓	–	LT spike	CE	–
Kulshrestha et al. [40]	A2	70	✓	✓	NM	6	DHS	✓	–	✓	✓	–	Long screw for LT fixation	Ligation	Nonunion, LT resorp-tion megapros-thesis
Pengrung et al. [56]	NM	72	NM	NM	NM	18	DHS	–	✓	–	–	–	Screw?	Hematoma removal, endo–aneurysm-orrhaphy	–
Hamdulay and Beres-ford [21]	A2	NM	NM	✓	NM	1	DHS	✓	✓(Pul-satile)	✓	✓(↓Hct)	Erythema Tachycar-dia Shortness of breath	LT spike	Resection	–
Jha et al. [29]	A1	78	No	No	NM	7 days	DHS	✓	–	✓(thrill, bruit)	–	–	Screw	CE	–
Jha et al. [29]	A1	69	No	No	NM	4	PFNA	✓	–	✓	–	–	Guide wire	CE	–

Hct, Haematocrit; CE, coil embolization; CHF, congestive heart failure; DHS, dynamic hip screw; DVT, deep vein thrombosis; LT, lesser trochanter; NM, not mentioned; PFA, profunda femoris artery; PFNA, proximal femoral nail antirotation; SFA, superficial femoral artery; ?, unclear cause

Table 2 Review of studies with pseudoaneurysm of the profunda femoris artery after intertrochanteric fracture fixation published during 2000–2022 (74 cases)

Factor		n (%)
Age mean (min, max)		74.82 (25, 97)
AO Classification	A1	17 (22.97)
	A2	44 (59.46)
	A3	2 (2.70)
Characteristics	LT displacement	44 (59.46)
	Shaft displacement	13 (17.57)
	Atherosclerotic vessels	7 (9.46)
Clinical symptoms and signs	Pain	52 (70.27)
	Mass (pulsatile)	18 (24.32)
	Swelling	63 (85.14)
	Decreased Hct/Hb	46 (62.16)
Onset	< 7 days	22 (29.73)
	7–28 days	23 (31.08)
	> 28 days	27 (36.49)
Implant	DHS	37 (50.00)
	PFN	35 (47.29)
	Others	2 (2.70)
Cause	LT spike	30 (40.54)
	Drill	14 (18.92)
	Screw	14 (18.92)
	Drill or screw	5 (6.76)
	Guide wire	2 (2.70)
	Shaft displacement	2 (2.70)
	Others	7 (9.46)
Treatment	Coil embolization	38 (51.35)
	Resection	9 (12.16)
	Repair	7 (9.46)
	Ligation	6 (8.11)
	Stent	6 (8.11)
	Other	8 (10.81)

Hb, Haemoglobin; Hct, Haematocrit; DHS, dynamic hip screw; LT, lesser trochanter; PFA, profunda femoris artery

was the most common cause of PFA injury (40.54%). Over-penetration with a drill and screw over-length were also common (18.92%). The data from the literature review are shown in Table 2, and the predisposing factors, signs and symptoms, and causes of pseudoaneurysms are shown in Table 3.

Conclusion

A pseudoaneurysm is rare but it is the most common vascular injury associated with proximal femoral fracture fixation. Fracture configurations such as a long spiral fracture or lesser trochanteric involvement or excessive shaft displacement are common risk factors for vascular injury. Being aware of possible profunda femoris artery injury is crucial when performing surgeries in this area. Performing fixation with a proper technique of cerclage wiring, distal screw length selection and drilling, may help prevent this serious complication.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

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Table 3 Summary of possible causes of vascular injury and prevention

	Details
Predisposing factors	Fracture characteristics, e.g. lesser trochanter displacement, shaft displacement, long spiral fracture Atherosclerotic vessels
Signs and symptoms	Mass (may be pulsatile), swelling and pain are common Inappropriately low haematocrit
Causes	Fracture configuration and displacement Deep retractor insertion Reduction technique, large perineal pole Blunt trauma Iatrogenic causes, e.g. over-penetration of drilling, cerclage wiring, manipulation (internal rotation and adduction), screw protrusion Note: acute presentation may be related to the penetration of a fracture spike or over-penetration of drilling. Delayed presentation may be associated with protrusion of screw or atherosclerotic vessels
Investigation	Ultrasonography: yin-yang sign, to-and-fro pattern CTA: contrast-filled sac with low-attenuation area MRI: cystic mass with multistage blood components
Treatment	Coil embolization Resection

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