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ORIGINAL ARTICLE • HIP - FRACTURES

Complications following proximal femoral locking compression plating in unstable proximal femur fractures: medium-term follow-up

Sandro Hodel[1] · Frank J. P. Beeres[1] · Reto Babst[1] · Björn-Christian Link[1]

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Abstract
Purpose To assess the outcome in patients treated with proximal femoral locking compression plate (PF-LCP 4.5/5.0, Synthes©) for unstable inter- and subtrochanteric femoral fractures.
Methods A retrospective analysis of 16 patients with proximal femur fractures (AO: 31A2: $n = 5/32.3\%$; 31-A3: $n = 10/62.5\%$; 32B1: $n = 1/6.3\%$) treated with a PF-LCP at a Level 1 trauma centre between 2011 and 2015 was conducted.
Results Sixteen patients were available for follow-up with a mean follow-up time of 14 months (range 4–29). Primary outcome included fracture healing, post-operative complications and post-operative ambulatory status. Male to female ratio was 1:1. Mean age was 61 ± 17 years. Union was achieved in a mean of 13.5 ± 3 weeks (range 12–20 weeks). Five patients (31.3%) had implant-associated complications like non-union, malrotation, late implant-associated infection, distal screw fractures and post-traumatic impingement of the hip. Consequently, four patients (25%) had to undergo revision surgery. There was no reported case of secondary varus collapse or cut-out.
Conclusions Complications occurred in 31.3% ($n = 5$) in medium-term follow-up after PF-LCP in proximal unstable inter- and subtrochanteric femur fractures. These findings are supported by results of other groups. However, further studies to evaluate risk factors associated with failure of this implant are required.

Keywords Pertrochanteric fracture · Intertrochanteric fracture · Subtrochanteric fracture · Plate osteosynthesis

✉ Björn-Christian Link
bjoern-christian.link@luks.ch

[1] Department of Orthopaedic and Trauma Surgery, Luzerner Kantonsspital, 6000 Luzern 16, Switzerland

Introduction

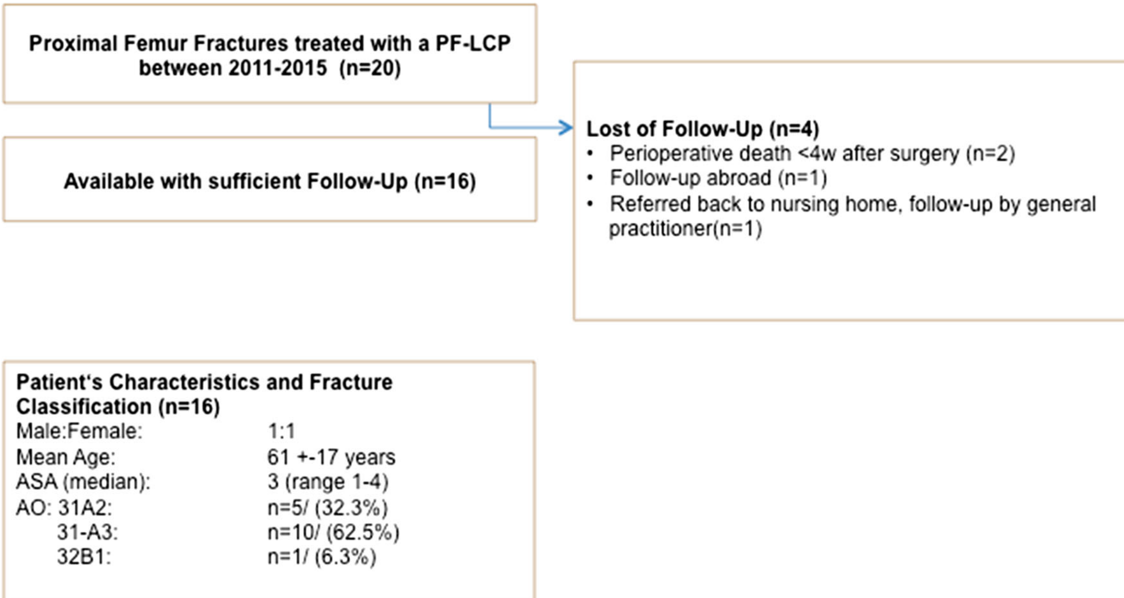
Almost 50% of proximal femur fractures are classified as inter-/pertrochanteric or subtrochanteric fractures [1]. Therapy of unstable pattern of these fractures remains a challenge due to the complexity of reducing and the difficulty of retaining them. Typically, these fractures happen in the elderly adding complicating factors like poor bone quality and incapacity to limit weight bearing.

Various intra- and extramedullary implants are available for stabilizing these fractures, such as dynamic condylar screw (DCS), dynamic hip screw (DHS), angled-blade plates and intramedullary nails. Secondary varus collapse, screw cut-out and implant failures are the most common implant-associated complications reported in this group of fractures [2–8].

The introduction of the proximal femoral locking compression plate (PF-LCP 4.5/5.0, Synthes©) provided an additional extramedullary treatment option. Advocated advantages are, that the precontoured plate allows for anatomical reduction and fixation against the plate, and improved fixation stability by the convergent cannulated proximal locking screws, especially in osteoporotic bone [9]. However, several studies reported high-failure rates associated with this implant, such as implant failure, secondary varus collapse and screw cut-out. To prevent these complications, previous authors outlined the importance of anatomical reduction and medial calcar support to prevent secondary varus collapse and implant failure [2, 10–18].

The aim of this study was to assess the outcome of our patients, who sustained a subtrochanteric or inter-/

Table 1 Flow chart and patients characteristics



pertrochanteric femur fracture and were treated with a PF-LCP at our institution.

Materials and methods

A retrospective analysis of 16 patients with proximal femur fractures treated with a PF-LCP at a Level 1 trauma centre between 2011 and 2015 was conducted. Inclusion criteria were the presence of a inter-/pertrochanteric, reversed intertrochanteric or subtrochanteric fracture, patient age over 18 years, no additional ipsilateral fracture and the ability to walk prior to injury with or without walking-aid. A sufficient follow-up was fulfilled when there was proof of radiological fracture union and the patient reported attainment of preoperative ambulatory status. Patient with pathological fractures and patients without sufficient follow-up were excluded.

Patient's data were acquired from electronic patient's charting system. Fractures were classified according to Arbeitsgemeinschaft für Osteosynthesefragen (AO) [19]. Fracture healing was defined, and post-operative status and post-operative complications were evaluated. Any discrepancies were resolved through a consensus discussion between the authors.

Primary endpoints were defined as radiological fracture healing (union, delayed-union or non-union), post-operative ambulatory status and post-operative complications. Fracture union was defined as radiological signs of fracture healing in three out of four cortices in conventional radiography or consolidation in computed tomography [20]. Delayed-union was defined as missing radiological fracture healing after 6 months or no progressive signs of fracture healing in between the three- and 6-month controls. Non-union was defined as missing radiological fracture healing after 9 months or no signs of progression of fracture healing in between the three- and 6-month control [21]. Displacement of calcar fragments was measured and categorized (<2, 2–5, >5 mm). Ambulatory status and post-operative complications were obtained from medical reports. Osteoporosis was diagnosed when dual energy X-ray absorptiometry (DXA) was pathological less than or equal to −2.5 [22]. American society of Anaesthesiology-Score (ASA-Score) was obtained from anaesthetic protocol. Dementia was defined as a pathological Mini-Mental-Test (less than 24 points) [23]. Duration of surgery and blood loss during surgery were obtained from the anaesthetist's report.

Secondary endpoints were to assess potential risk factors for delayed fracture healing, post-operative complications and the time to full weight bearing.

Surgical technique

Patients were positioned supine. All patients received a single-shot of intravenous Cefazolin 2 g 30 min before operation. Fluoroscopic image intensifier was used to guide intraoperative reduction and internal fixation. No

Table 2 Post-operative complications and treatment ($n = 5$)

Gender	Age	MOI[a]	Comorbidities	Complication	Treatment
M	69	Fall (low energy)	ASA III osteoporosis	Inadequate reduction, non-union	Conversion to angled-blade-plate and total hip prosthesis
M	43	MVA[b] (high energy)	No comorbidities	Malrotation	Bone allograft and plate relocation
M	85	Fall (low energy)	ASA III chronic lymphedema	Late implant-associated infection	Plate removal, debridement and spacer implantation
F	52	Fall (low energy)	ASA III osteoporosis	Distal screw fractures	Additional screw fixation
F	56	Sports (high energy)	ASA II	Post-traumatic impingement of the hip	Non-operative treatment

[a] Mechanism of injury

[b] Motor vehicle accident

traction table was used. A lateral minimally invasive or when necessary a conventional lateral approach was used. The fractures were reduced by proximal fixation of the angular stable screws in the head neck fragment and then using the plate as a reduction tool to align the fractured shaft fragments. If needed, the femoral head and neck were displayed through an anterolateral approach.

Post-operative protocol

Patients were allowed for partial weight bearing (15–20 kg) from the second post-operative day. If patients were not able to comply with partial weight bearing, wheelchair transfer was conducted. Further weight bearing followed according to clinical and radiological assessment of fracture healing. Low molecular weight heparin was administered post-operatively in prophylactic dosage until full weight bearing was achieved. Clinical and radiological follow-up is routinely performed 6 weeks, 3, 6 months and 1 year post-operative at our department.

Statistics

Prior to analysis of data, demographics and outcomes were evaluated for normal distribution and assessed by histograms. All statistical tests were discussed with an independent statistician. Binomial data are presented as the number and percentage. Continuous data are presented as mean or median ± standard deviation. Subgroup analysis for numeric values was performed with the Mann–Whitney *U* test for skewed data. Categorical data were compared using the Chi-square test and Fisher's exact test. All data were analysed using SPSS software (version 22; IBM©). A two-sided p value of <0.05 was considered significant.

Results

Sixteen patients met the inclusion criteria, while four were excluded due to short follow-up (see Table 1). Medium follow-up was 14 months (range 4–29 months). Two patients died within the fourth post-operative week (both ASA-Score 4). One patient was referred for follow-up to his regional hospital abroad, and one patient was referred back to the nursing home. She was followed up by her general practitioner and returned to ambulatory status with a walking-aid 4 months post-operatively (see Table 1).

Eight male and eight female patients treated with a PF-LCP with a mean age of 61 ± 17 years were included for statistical analysis. Median ASA-Score was 3 (range 1–4). Twenty-five per cent ($n = 4$) of the patients had confirmed osteoporosis. In three patients (18.7%) dementia was diagnosed. Mechanism of injury was low-energy, respectively, high-energy trauma in 50% ($n = 8$) each. Preoperatively, all patients were ambulators.

Each of the 16 patients presented with only one proximal femoral fracture (AO: 31A2: $n = 5/32.3\%$; 31-A3: $n = 10/62.5\%$; 32B1: $n = 1/6.3\%$) (see Table 1). All patients underwent osteosynthesis with a PF-LCP performed by a senior trauma surgeon. The rationale for the use of the PF-LCP was either a reversed intertrochanteric fracture pattern or the fracture line extending to the greater trochanter and therefore compromising the entry point of a possible intramedullary device. No perioperative complications, including post-operative bleeding or superficial wound infection, were reported. Mean operating time was 184 ± 74 min. Mean blood loss was 549 ± 626 ml, and duration of hospital stay was 7 ± 4 days. Most patients ($n = 12/85.6\%$) could comply with the post-operative protocol of partial weight bearing. Two patients (14.2%) were not able to partially weight bear. Therefore, wheelchair transfer was conducted and weight bearing allowed at

Fig. 1 Successful plate application and uneventful healing. **a** Preoperative X-ray anterior–posterior and lateral of a 54-year-old patient with a reversed intertrochanteric fracture (AO: 31 A3). **b, c** Post-operative X-ray anterior–posterior and lateral proximal. **d, e** Uneventful healing with fracture consolidation 3 months post-operative

12 and 14 weeks post-operatively. Overall, full weight bearing was permitted after 11 ± 3 weeks.

Fifteen patients (93.7%) achieved union in a mean time of 13.5 ± 2.4 weeks. Altogether in five patients (31.3%) complications occurred and four patients (25%) underwent revision surgery (see Table 2).

One patient (6.3%) had to be revised with an angled-blade plate after 5 days due to malpositioning and inadequate reduction. Due to a non-union a total hip replacement was successfully performed 6 months after the initial trauma.

In another case, 13 months post-operatively, implant-associated late infection led to removal of the plate, recurring debridement and implantation of an antibiotic spacer. Intraoperative, a stable situation was found which indicated a consolidated fracture, and no further fixation was performed. After removal of the antibiotic spacer the patient went back to ambulatory status with a wheeled walker 1 year post-operatively (Fig. 1).

Another patient, unable to comply with post-operative partial weight bearing, broke three distal screws with consecutive displacement of the plate 6 weeks post-operatively and underwent revision by additional screw fixation (see Fig. 2). Further implant-associated complications, such as malrotation and symptomatic impingement of the hip occurred in two other cases (see Table 2). The malrotation was surgically corrected after 5 days of the index surgery, and refixation was performed using the same PF-

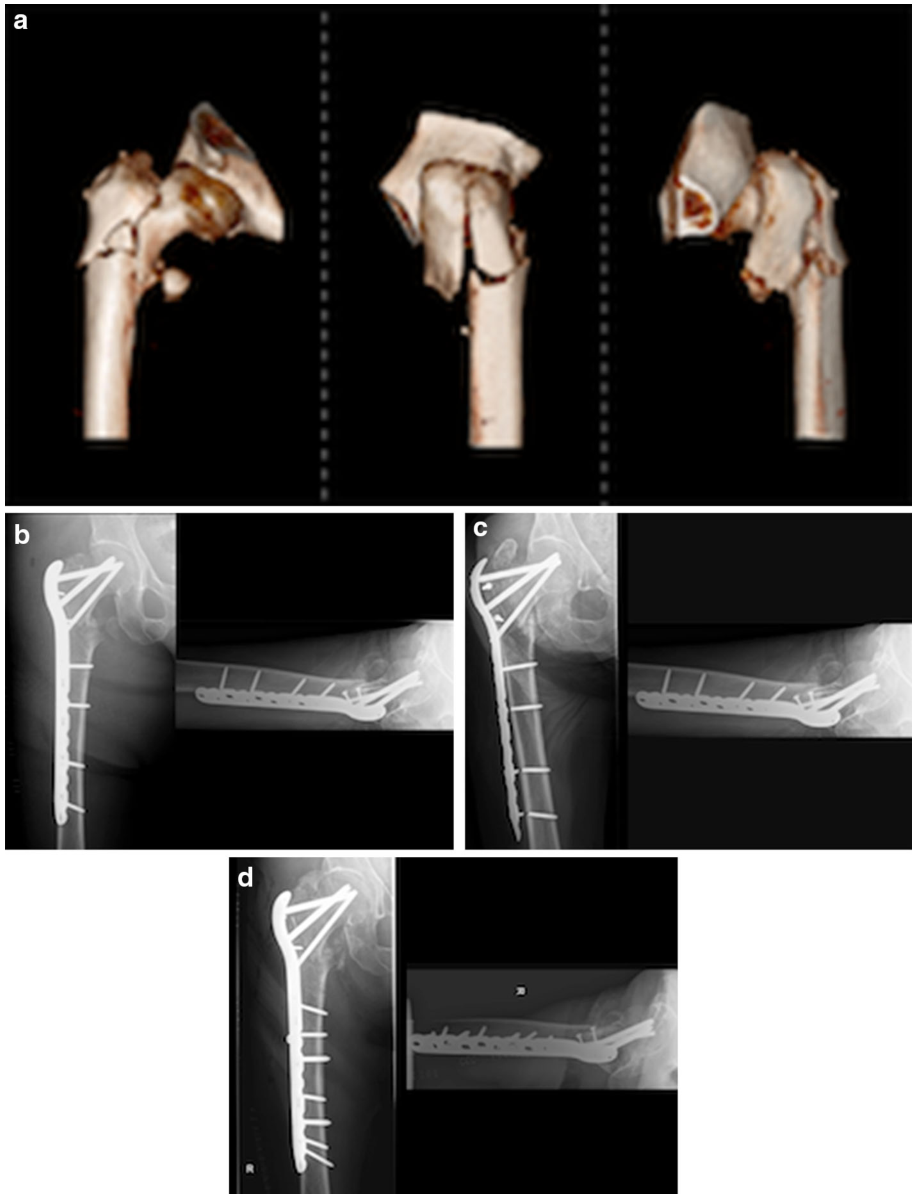


Fig. 2 Example of distal screw failure 5 weeks post-operative. **a** Preoperative 3d-scan right hip (reconstruction of whole-body-computer-tomography) anterior/lateral/posterior of a 52-year-old patient with a reversed intertrochanteric fracture (AO: 31 A3). **b** Post-operative X-ray. **c** Distal screw fractures 5 weeks post-operative. **d** Revision surgery with additional screw fixation

LCP. The symptomatic impingement did not undergo surgery because of only minor symptoms.

There was no secondary varus collapse or cut-out reported. At the end of the follow-up all patients (100%) were ambulators.

Subgroup analysis did not reveal any significant risk factors for primary endpoints. Higher complication rates were reported with ASA-Score >3, operation time >160 min and a displacement >5 mm (see Table 3).

Discussion

Several studies have shown the risk of secondary varus collapse and implant failure to be associated with application of a PF-LCP in sub- and intertrochanteric fractures [2, 10–18, 24]. Johnson et al. [14] reported a higher complication rate with age and female sex. Interestingly, our results do not support this (see Table 3). However, in our study the incidence of complications ($n = 5$, 31.3%) and revision surgery ($n = 4$, 25%) is comparable to several previous studies that reported complication rates up to 70% [2, 10–18].

In our series of patients, complications occurred only with an ASA-Score ≥2, mainly in reversed intertrochanteric fractures (AO: 31 A3) ($n = 4$, 80%) and mainly with calcar displacement >2 mm ($n = 4$, 80%) (see Table 3). These findings support the importance of an anatomical reduction and an intact medial buttress for prevention of failure especially in unstable fracture patterns [10, 25, 26]. Unlike the use of a sliding-hip screw or a

Table 3 Subgroup analysis of risk factors associated with primary endpoints ($n = 16$)

Subgroup	Radiological fracture healing (n/%)[a]	Radiological fracture healing in weeks (±SD)[a]	Post-operative complication (n/%)
Male	7/87.5%	12 ± 5.2	3/37.5%
($n = 8$)	($p = 1$)	($p = 0.64$)	($p = 1$)
Female	8/100%	13.3 ± 2.8	2/12.5%
($n = 8$)	($p = 1$)	($p = 0.64$)	($p = 1$)
>60 years	7/87.5%	11.6 ± 5	2/12.5%
($n = 8$)	($p = 1$)	($p = 0.69$)	($p = 1$)
<60 years	8/100%	13.6 ± 2.9	3/37.5%
($n = 8$)	($p = 1$)	($p = 0.69$)	($p = 1$)
ASA ≥ 3	12/100%	12.4 ± 4.6	4/30%
($n = 12$)	($p = 1$)	($p = 0.64$)	($p = 0.25$)
ASA < 3	3/75%	13.2 ± 1.9	1/25%
($n = 4$)	($p = 1$)	($p = 0.64$)	($p = 0.25$)
Operation time	7/100%	12.9 ± 1.2	1/14.3%
<160 min ($n = 7$)	($p = 1$)	($p = 0.95$)	($p = 0.3$)
Operation time	8/88.9%	12.4 ± 5.6	4/44.4%
>160 min ($n = 9$)	($p = 1$)	($p = 0.95$)	($p = 0.3$)
Blood loss	4/100%	12 ± 1	1/25%
<250 ml ($n = 4$)[b]	($p = 1$)	($p = 0.15$)	($p = 1$)
Blood loss	7/87.5%	12.7 ± 5.7	2/25%
>250 ml ($n = 8$)[b]	($p = 1$)	($p = 0.15$)	($p = 1$)
Low-energy trauma	7/100%	12.6 ± 1.5	2/28.6%
($n = 7$)	($p = 1$)	($p = 0.29$)	($p = 1$)
High-energy	8/88.9%	12.7 ± 5.4	3/30%
Trauma ($n = 9$)	($p = 1$)	($p = 0.29$)	($p = 1$)
Reversed	9/90%	11.8 ± 4.4	4/40%
Intertrochanteric	($p = 1$)	($p = 0.68$)	($p = 0.59$)
(AO: 31A3) ($n = 10$)			
Non-reversed	6/100%	14 ± 3.3	1/16.6%
Intertrochanteric ($n = 6$)	($p = 1$)	($p = 0.68$	($p = 0.59$)
Displacement <2 mm	3/100%	14.7 ± 4.6	1/33.3%
($n = 3$)	($p = 1$)	($p = 0.92$)	($p = 0.78$)
Displacement 2–5 mm	6/100%	12.8 ± 1.3	1/16.7%
($n = 6$)	($p = 1$)	($p = 0.92$)	($p = 0.78$)
Displacement >5 mm	6/85.7%	11.6 ± 5.4	3/42.9%
($n = 7$)	($p = 1$)	($p = 0.92$)	($p = 0.78$)

All patients were ambulators post-operative (100%)

[a] One patient showed no signs of fracture union

[b] In four patients the amount of blood loss was not recorded in the theatre report

proximal femoral interlocking nail, the PF-LCP does not allow controlled fracture collapse and is therefore relying on inherent stability that derives from restoration of the medial buttress [2, 10, 27].

Complication and failure rates reported with the use of proximal femoral nails, angled-plates and DHS in unstable intertrochanteric fractures range from 3 to 26% [28–31]. To our knowledge there is only one study comparing the PF-LCP to other implants. Nayer et al. [25] analysed complication rates and functional outcome of PF-LCP and DHS, but found no significant differences. On the other hand, several biomechanical studies describe decreased fracture stability with the use of the PF-LCP compared to intramedullary devices. Nevertheless, maximum axial loading force was higher compared to dynamic condylar screw (DCS) and angled-blade plates [26, 32, 33].

The results show that the application of the PF-LCP may be justified for its superior abilities to restore and maintain anatomy (see Fig. 1). This especially holds true for a younger subgroup of patients. However, if anatomical reduction is not achieved and patient compliance is low, the usage of a PF-LCP should be carefully weighed against other implants especially in unstable intertrochanteric or subtrochanteric fractures.

Limitations of our study are its retrospective study design and the loss to follow-up in 20% of cases ($n = 4$). We were not able to determine any significant risk factors associated with radiological fracture healing, time to radiological fracture healing and post-operative complications using a subgroup analysis. This is likely due to the small sample size of our study. Therefore, further, preferably prospective studies are needed to identify potential risk factors for non-union, implant failure or secondary varus collapse with the use of the PF-LCP in inter-/pertrochanteric, subtrochanteric and reversed intertrochanteric fractures.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Compliance with ethical standards

Conflict of interest Sandro Hodel, Frank J. P. Beeres, Reto Babst, Björn-Christian Link declare that they have no conflict of interest.

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