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# Treatment of periprosthetic femoral fractures of the knee

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**Abstract**
*Purpose* We report a continuous series of periprosthetic femoral fractures after knee arthroplasty treated with a locking plate. We hypothesize that minimally invasive surgery and immediate weight-bearing improve functional recovery.
*Methods* From June 2002 to December 2008, 15 patients with 16 fractures were treated. Median age was 81 years. The autonomy level according to the mobility score of Parker and Palmer showed a median of 5 (0–9). Osteosynthesis was performed mainly through a minimally invasive approach using a locking compression plate. The rehabilitation protocol consisted of immediate mobilization and, whenever possible, immediate unrestricted weight-bearing.
*Results* Five patients died during follow-up, more than 1 year after osteosynthesis. Their results were included. Autonomy and mobility were preserved with a median postoperative score of 4 (0–9) according to Parker and Palmer. The consolidation rate was 93.8%, which was obtained within 10 weeks. There were no mechanical or infectious complications. Fourteen cases were treated with minimally invasive surgery without fracture exposition; the remaining 2 required a slightly more extended approach. Full weight-bearing occurred 10 times; 20-kg partial weight-bearing was advised twice; and on 4 occasions, no weight-bearing was allowed for 6 weeks.
*Conclusion* Osteosynthesis with a minimally invasive bridge-plating technique is effective in the treatment of periprosthetic, distal femoral fractures without component loosening. Immediate full weight-bearing is possible if certain rules are respected. The surgical management presented herein is beneficial for these challenging fractures, and it may help reduce the complication rate and improve functional outcome.
*Level of evidence* IV.

**Keywords** Fracture on total knee prosthesis · Femoral fracture · Locking plate · Mini-invasive surgery

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## Introduction

Femoral fractures occurring on knee implants are rare, with rates ranging from 0.3 to 2.5%. Nevertheless, it has increased in importance because of ageing of the population [2]. In preliminary studies, we reported satisfactory results of patients who presented with femoral fractures on previous implants treated with locking plates and immediate weight-bearing [8, 10]. We consider periprosthetic femoral fractures on elderly patients, such as proximal femoral fractures, to have a grave prognosis. Indeed, Zuurmond et al. [36] reported an elevated revision rate of more than 1 out of 2 unsatisfactory results, compared with primary arthroplasty. Bhattacharyya et al. [3] confirmed the severity of these fractures. He reported a substantial mortality rate, which was statistically higher than that of a similar population and comparable to that of hip fracture patients. We hypothesize that minimally invasive surgery

with use of a locking plate and immediate postoperative weight-bearing is essential for the functional recovery of these elderly patients. Through a retrospective series of 16 periprosthetic femoral fractures, we try to validate our statement.

## Materials and methods

All periprosthetic femoral fractures around a knee arthroplasty treated by a locking compression plate (LCP; Synthes, West Chester, PA) between June 2002 and December 2008 were included**.** During this period, only 4 femoral fractures were treated by intramedullary nailing. A series of 16 patients were reported, with 15 women and 1 man. The median age was 81 years (58–89), and the median body mass index (BMI) was 29 (21–40). The preoperative mobility score, according to Parker and Palmer [24], showed a median of 5 (1–9). The femoral fractures were isolated and secondary to low energy trauma. All the implants were cemented and stable. There was no hip arthroplasty on the same side. There were 15 total knee arthroplasties (TKAs), of which 1 was a revision arthroplasty with a long femoral stem, and 1 was a medial unicompartmental resurfaced knee. Only 2 TKAs had been performed in our institution, with a preoperative range of motion of 0–120° and 0–90°, respectively. The average time between arthroplasty and fracture was 8.7 years (2–16). All the fractures were at the distal third of the femur. There was no open fracture. The fractures were spiral (7), transverse (5) or oblique (4). According to the SOFCOT classification, there were 6 type B1 and 10 type C fractures (Fig. 1) [30]. This classification has 3 types: type A corresponds to a unicondylar fracture of the tibia or femur; type B, to a fracture at the level of the tibial or femoral component; and type C, to a fracture distant from the prosthesis. Subclassification in 1, 2 and 3 indicates the quality of fixation of the components.

Surgical procedures were performed according to a technique previously described [8–10]. Implants consisted of an anatomical, not modified or distorted distal femoral locking plate; less invasive stabilization system (LISS; Synthes, West Chester, PA). The procedure was performed on either a traction table or a classic table with the patient in a supine position, depending on the surgeon's preference. In order to decrease preoperative exposure to radiation, cutaneous landmarks such as fracture level, prosthesis, joint, approach site, A-P and lateral femoral axes were drawn. The approach was usually minimally invasive, using a lateral paracondylar incision. Reduction was always attempted using external manoeuvres under fluoroscopic control: traction, valgus/varus (by using the traction table or an assistant if a conventional table was

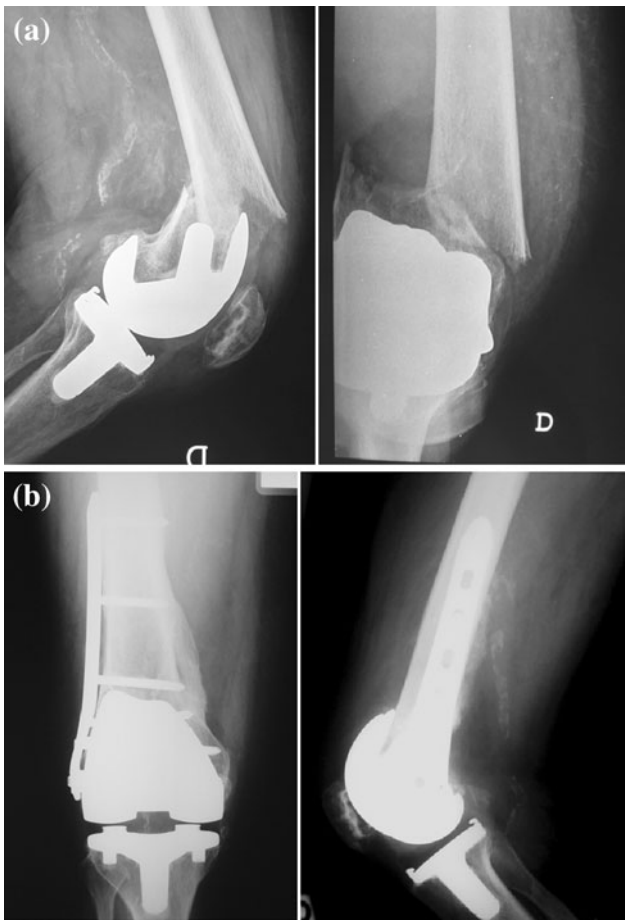


**Fig. 1** Distal femoral fracture on a total knee arthroplasty, type C according to the SoFCOT Classification. **a** Preoperative roentgenogram. **b** At latest follow-up (2, 5 years) roentgenogram, following immediate postoperative weight-bearing

used) and cushion under the distal fragment if the fracture was distally situated to counteract recurvatum due to the influence of the gastrocnemius muscles or hamstrings. On a traction table, the same was achieved with a posterior support, which was mounted on the table and positioned underneath the distal fragment to avoid the recurvatum. If the reduction was insufficient, we used additional techniques as already described: anatomical shape of the distal femoral plate with parallel articular epiphyseal screws, use of standard lag screws or temporary intrafocal pinning to control the sagittal or frontal axis [8–10].

The aim was to obtain a global reduction of the segment and reconstruct the anatomical axis. The goal of osteosynthesis was to obtain a long construct with 5 holes beyond the fracture on the proximal femur and by alternating free holes with locked ones to allow better force distribution over the construct and to reduce local strain [14]. Screws had to be bicortical and spaced. If prosthetic cluttering due to long stems did not allow bicortical screws,

then tension band wiring was performed to avoid pulling-out of the plate. In case of a complex fracture, good practice requires that locking screws be close to the fracture line and be at a distance when the fracture is simple to benefit from the titanium's elasticity. If the described procedure was specifically followed and patient's pretraumatic autonomy was sufficient with a Parker and Palmer score of at least 3 or 4, then immediate, postoperative, unrestricted weight-bearing was permitted [8–10]. The type of fracture was not a criterion in the decision to allow full weight-bearing. Only the quality of the constructs and the patient's preoperative mobility score were essential to us. Knee mobilization was immediate in all cases.

With elderly patients, the most suitable criterion for clinical evaluation is the level of autonomy [8, 10]. The problem is not that of range of motion of the TKA but the functional recovery and global autonomy of the patient. Therefore, at the latest follow-up, clinical evaluation was based on the Parker and Palmer score [24].

Radiographic evaluation consisted in assessing the first occurrence of fracture consolidation, defined as the appearance of a bony callus on at least 2 cortices. Furthermore, anatomical axes were assessed in order to detect any malunion. Thus, the anatomical axis of the proximal fragment was compared with the anatomical axis of the distal fragment [8, 10]. Any deviation of more than 10° in an A-P or strictly lateral standard X-ray was considered to be pathological. Rotation was evaluated clinically on a horizontal level [8, 10]. We compared the immediate postoperative roentgenogram with those obtained at the latest follow-up. Two independent senior surgeons made the radiographic measurements.

## Statistical analysis

For statistical results, a Student's $t$ test was used with a positivity threshold of $P < 0.05$ to compare the Parker scores. To compare the Parker score and the postoperative range of motion (ROM), we used a nonparametric test (Spearman) for quantitative variables.

## Results

Sixteen patients had a radio-clinical evaluation at a median 36.5-month (14–72) follow-up. Five deceased patients were reported because they had a minimal follow-up of 12 months (14–72). The procedure was performed on a standard table 9 times and on a traction table 7 times. Minimally invasive surgery was performed 14 times (88%). In 2 cases, the approach needed extending: 1 case to dislodge a muscular interposition and another with a long revision stem to place a tension band wire (Fig. 2). Twice (12%) a classic lateral approach was performed, because of the surgeon's preference, with no specific justification. Immediate full weight-bearing was allowed 10 times; 20-kg partial weight-bearing within 6 weeks was advised twice due to a comminuted fracture in the early stages of our study; and in 4 fracture cases, no weight-bearing was allowed for 6 weeks in patients with a preoperative reduced autonomy with a Parker and Palmer score of 2 or less. At revision, the autonomy score was preserved with median of 4 (0–9). The $P$ value between preoperative and postoperative mobility score was not significant ($P = 0.62$). Mean ROM was 0–100° (range, 0–60° to 0–120°). For the 2 patients operated in our institution, the postoperative ROM was identical to that after primary surgery**.** There was no correlation between the postoperative ROM and the Parker and Palmer score. No infectious, general or decubitus complication was reported. There were no mechanical complications due to failure of the implant.

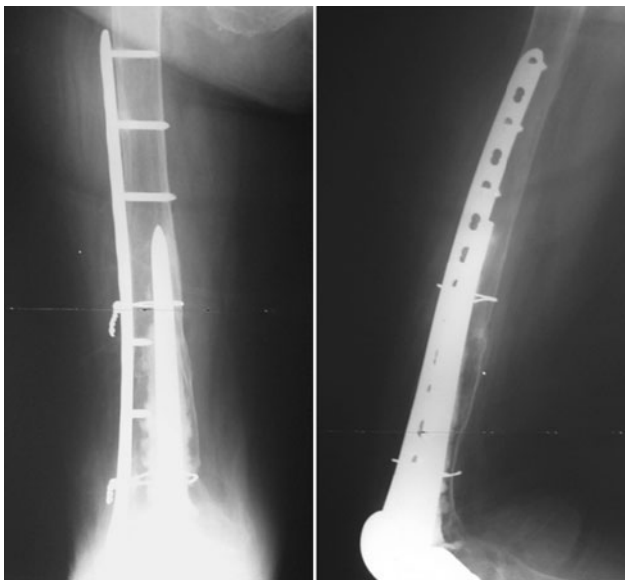

**Fig. 2** Femoral fracture on a revision femoral stem, type B1 according to the classification of the SoFCOT. Use of cerclage because of the stem cluttering to avoid pulling-out of the plate. Two-year follow-up roentgenogram

Radiographical consolidation was obtained in all but one case (93.8%). Nonunion was not treated because it was well tolerated and because of the patient's critical cardiovascular history. The ROM of this patient was 0–60°.

Mean consolidation time was 10 weeks (8–12). No axial deviation over 10° was noted. At latest follow-up, axis correction was stable despite postoperative weight-bearing. No modification of the implant's stability was found at latest follow-up.

## Discussion

The most important finding of the present study was the quality of functional recovery and the possibility of immediate weight-bearing after surgery. Preliminary reports were published with interesting results concerning periprosthetic femoral fractures treated with locking plates, minimally invasive surgery and immediate weight-bearing [8, 10]. We are convinced of the benefits of this management on functional recovery and prevention of decubitus complications.

Periprosthetic femoral fractures are known for their severity [3, 36]. We have tried to optimize the handling of these patients looking for a faster and better functional recovery and to maintain a high degree of autonomy in this fragile segment of population.

Many authors have proved that locking plates associated with minimally invasive surgery are well adapted to fractures on TKA [13, 17–19, 21–23, 27, 29, 32, 34]. Indeed, this hardware permits good fixation in osteoporotic bone, which is essential for a successful result [20, 26, 31].

Besides this, a minimally invasive approach with closed fracture reduction allows preservation of both fracture haematoma and periosteal vascularization, which contribute to successful consolidation, with a good callus as seen in intramedullary nailing [11, 25]. The radio-clinical results we report are satisfying, encouraging and comparable with other reports from the literature [13, 17–19, 21–23, 27, 29, 34]. The consolidation rate was excellent, there were no complications due to mechanical failure or decubitus, and functional recovery was noticeable with a conserved autonomy. Our series is distinguishable from published data for its rehabilitation regimen where weight-bearing is allowed immediately postoperatively.

Combining a stable assembly with minimally invasive surgery allows full weight-bearing if the mechanical specifications of the construct are respected and the preoperative autonomy is sufficient [8–10]. This association is essential. To our knowledge, no team has reported immediate postoperative weight-bearing. Our results confirm the hypothesis of functional recovery after minimally invasive surgery associated with immediate weight-bearing. According to our radiographic findings, weight-bearing is possible without major risks of failure of the hardware or secondary loss of reduction over time. Mechanical failures have been reported in the literature, despite restrictions in weight-bearing in postoperative rehabilitation [13, 17, 27, 32]. Therefore, the mechanical specifications we propose seem clinically validated by our results. Interest in anatomical plates resides in the possibility of multiple anchoring by locked screws in the distal fragment with angular stability of the converging screws. In long assembly, proximal locking is spaced, and screws are always bicortical to allow better distribution and absorption of constraints.

Mechanical studies have proven the stability of the LISS device compared with more common constructs. Fulkerson et al. [12] compared the fixation of periprosthetic femoral fractures with LCP locking plates and conventional plates associated with wiring. Both systems were submitted to continuous cyclic loading. LCP plates showed increased resistance to continuous axial loading and torsion. Zlowodzki et al. [35] compared LCP constructs with blade plates and retrograde nails in supracondylar fractures of the femur. An LCP construct showed increased resistance in axial compression of 34% compared with a blade plate and 13% compared with a retrograde nail. However, resistance to torsion was less for the LCP construct. This relative weakness might be explained by the monobloc characteristics of the LCP construct. These authors observed a better fixation in the distal part with only 1 failure with the LCP construct in 16 cases, 3 failures out of 8 cases with the blade plates and 8 failures out of 8 cases with the retrograde nails. They concluded that excellent bony fixation occurred in the distal fragment, especially in the case of osteoporotic bone.

Higgins et al. [16] have proved the mechanical superiority of LCP constructs over blade plates, using a cadaver model of a supracondylar femoral fracture with better absorption of axial loads, an increased load to failure, and better control of displacements secondary to axial loads. Results of comparative clinical series using different types of osteosynthesis led to the same conclusion. Herrera et al. [15] reported a systematic revue of 415 femoral fractures with TKA taken from 29 published studies. The following outcomes were noted: a nonunion rate, 9%; failure of fixation, 4%; infection rate, 3%; revision surgery rate, 13%. These results underline the interest of locking plates in treating distal periprosthetic fractures compared with conventional methods. Series specifically reporting results of locking plates brought together 57 patients. The nonunion rate was 5.3%; failure of fixation, 3.5%; infection rate, 5.3%; revision rate, 9%. These complication rates are clearly greater than ours.

Published data concerning retrograde nailing are controversial. Large et al. [21] compared the LISS device with conventional treatments such as retrograde intramedullary nailing (IMN) and nonlocking plates. They concur with the superiority of the LISS device, having fewer complications, iterative surgeries, malunions or pseudarthroses. For Wick et al. [32], the LISS seems to be a better alternative than IMN for periprosthetic fracture on TKAs when the distal fragment is small. Bong et al. [4], with a cadaveric study reproducing a compound fracture on a TKA, have proved the superiority of the nail compared with a LISS LCP construct. According to Herrera et al. [15], retrograde

nailing is associated with an 87% relative risk reduction of nonunion and a 70% relative risk reduction requiring revision surgery compared with conventional plating methods. Retrograde nailing has several limitations: the approach is articular; not all types of TKAs do accept a nail and it might be difficult to be aware of the precise type of TKA; a very distally located fracture or a homolateral total hip arthroplasty.

For the osteosynthesis, we follow specific mechanical guidelines: long assembly, alternating locked screws with free holes, bicortical locked screws, maximal fixation in the distal fragment and around long revision stems with specific flat-ended periprosthetic screws and eventual tension band wires around the stem to avoid pulling-out of the plate [8–10]. Recent biomechanical studies have confirmed this type of assembly, but they have also helped to improve it. For Dougherty et al. [7], bicortical screws will be used as often as possible. Button et al. [6] confirm this notion as they report 4 mechanical failures of distal femoral plates, of which 2 were progressive pull-outs at the proximal end of the plate that had been fixated by monocortical screws. They also underlined the importance of the position of the plate on the lateral view to avoid having the screws tangent to the cortex and compromise the fixation. In order to have a stiffer, more homogenous assembly, it is necessary to limit the gap between the plate and the bone [1]. They concluded that a gap less than 2 mm allows maximal fixation in compression and torsion. If the gap is over 5 mm, there is a major risk of plastic deformation if it is a stainless steel plate and a risk of plate fracture if it is titanium. LCPs have dual screw holes that allow its use as bridging plate ("internal fixator"), conventional compression system or both. A recent study compared the 3 ways of using the plates in cases of distal femoral fractures [28]. The internal fixator mode has the best axial compression stiffness but shows less plastic deformation. The compression mode better resists torsion. Therefore, the authors recommend using a combination of both techniques [28]. Bottlang et al. [5] recommend inserting 1 standard screw at the end of the plate to limit constraints and to avoid the risk of stress fractures by increasing flexion resistance without altering compression or torsion resistance. Finally, Wilkens et al. [33] demonstrated that polyaxial locked screws increase resistance in compression, torsion, loading and rupture and lead to less important plastic deformation after axial loading.

This study has several limitations. The number of cases is low. Follow-up time was limited because almost 33% of the patients died during the study period. Unfortunately, these limitations are inherent in an aged study population and the rarity of the pathology.

Full weight-bearing according to discomfort was allowed, but it remains difficult to evaluate how much weight-bearing actually was performed. Nevertheless, we believe that full weight-bearing was immediately started at the outset of rehabilitation, as these elderly patients are usually unable to perform partial weight-bearing.

## Conclusion

According to our results, locking plates are particularly well adapted to periprosthetic fractures of the femur. It helps us obtain a satisfying and stable reduction through time, both radiographically and clinically. Our radiographic results confirm the feasibility of minimally invasive surgery, and our clinical results prove the benefits of early weight-bearing. Therefore, if the assembly respects our guidelines, we recommend a minimally invasive approach with full weight-bearing whenever possible.

**Conflict of interest** ME and PA: consulting activity, no financial conflict for this study. LA, MR, BKM, YA, BF: none.

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