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ORIGINAL ARTICLE

# Periprosthetic femoral fractures treated by locked plating: Feasibility assessment of the mini-invasive surgical option. A prospective series of 36 fractures

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Accepted: 4 January 2011

## KEYWORDS

Femoral fracture;  
Peri-prosthetic fracture;  
Locking plate;  
Mini-invasive

## Summary

**Introduction:** The treatment of periprosthetic femoral fractures by conventional plating is associated with problems related to fracture union and eventual refracture. Additionally, locking nailing cannot be used in all cases because of the risk of malunion. To resolve these issues, locking plates have been proposed to combine the advantages of closed reduction and internal fixation while achieving a higher quality reduction with plate fixation.

**Hypothesis:** Locking plates put into place by a mini-invasive surgical approach result in fixation without substantial misalignment or non-union.

**Patients and methods:** From June 2002 to December 2007 we prospectively treated 35 patients (one bilateral), 28 women and seven men with a fracture around the hip implant (21), around the knee (8), between the hip implant and the knee (2), between a trochanteric internal fixation device and the knee implant (5). The mean age was 76, (39–93). Internal fixation was always attempted by mini-invasive surgery using locking plate system with locking screws (Synthès™). Rehabilitation included immediate weight bearing with as much weight as the patient would tolerate. The preoperative Parker score was 5.25 (0–9).

**Results:** There was one patient lost to follow-up, one early failure, and seven deaths (four of whom were included in the study group since their follow-up was at least 24 months) for a total of 31 fractures (30 patients), the mean follow-up for the series was 26 months (6–67). Twenty-six fixations were performed by mini-invasive approach and 10 through a conventional

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open surgery. Patients applied full weight ( $n = 20$ ), partial weight ( $n = 3$ ) or no weight for 6 weeks ( $n = 13$ ). Infections developed in two patients and there were three cases of mechanical failure. Fracture union was achieved in 35 out of 36 cases. More than  $5^\circ$  of misalignment was observed in five patients. Loosening of the implant did not occur in any patients during follow-up. The Parker score in patients seen at follow up was 4.3 (0–9).

*Discussion-conclusion:* Locking compression plates associated with a mini-invasive surgical approach result in a high rate of union (35/36) with no significant misalignment (only 5/36 cases of misalignment of more than  $5^\circ$ ), no refractures ( $n = 0$ ) and a low rate of mechanical failure (3/36) while allowing full weight bearing in most cases (20/36). Locking plates for periprosthetic femoral fractures allow patients to begin walking again, with stable intermediate term results.

*Level of scientific evidence:* Level IV. Prospective study with no control group.

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## Introduction

The frequency of periprosthetic femoral fractures is approximately 0.1–2% for total hip arthroplasties (THA) and 0.3–2.5% for total knee arthroplasties (TKA) [1]. This pathology is becoming more frequent because of the increase in the number of arthroplasties and of the ageing population. A preliminary study reported satisfactory results in a series of 21 patients presenting with a femoral fracture around an implant treated by locking compression plate with a mini-invasive biological approach (respecting the hematoma, periosteum and soft tissues) and immediate weight bearing. [2]. This trial was continued and we report a prospective continuous series of 36 periprosthetic femoral fractures in 35 patients.

The aim of this study was to evaluate the outcome of these fractures in a population of elderly subjects and report the risk of iterative fracture as well as to evaluate the feasibility and role of mini-invasive surgery in preserving the fracture hematoma.

## Patients and methods

### Patients

We included all periprosthetic femoral or knee fractures treated by the locking compression plate system with locking screws LCP (Synthès™) between June 2002 and December 2007. The series included 36 fractures with 28 women and seven men whose mean preoperative autonomy on the Parker score [3] was 5.25 (0–9). This included fractures around: a hip replacement ( $n = 21$ ), a knee replacement ( $n = 7$ ), a unicompartmental knee replacement ( $n = 1$ ), between the hip replacement and the total knee replacement ( $n = 2$ ), between trochanteric internal fixation and a total knee replacement ( $n = 5$ ). The mean age of patients was 76 years old (39–93, median = 79). According to the Vancouver classification of periprosthetic hip fractures [4] and the SOFCOT classification for periprosthetic knee fractures [5] the series included 24 type C fractures, 10 type B1 fractures, one type B2 fracture and one type B3 fracture. Twenty-one of these fractures were distal or supracondylar with a short horizontal or oblique fracture line and in 15 cases, proximal or mediadiaphyseal most often with an oblique or spiroid line.

## Surgical technique

The surgical technique was reported in a previous study [2]. Internal fixation was obtained with large fragment titanium plates and locking screws LCP (Synthès™). Two types of plates were used depending on fracture site: the diaphyseal anatomical plate or the distal femoral anatomical plate, which was chosen for distal fractures. The surgery was performed either on a traction table or a standard operating table. Installation depended upon the type of fracture and the surgeon's preferences. Schematically, the patient was installed on a standard table for treatment of fractures of the distal third and on an orthopedic table for fractures of the middle and proximal third of the femur. To reduce perioperative radiation, AP and lateral view cutaneous guide marks were drawn for the fracture, the implant, the knee joint, the incision site and the femoral axis. The surgical approach was mini-invasive and was adapted to the fracture site and type of plate by proximal paratrochanteric approach (high femoral fractures and diaphyseal anatomical plates) or paracondylar approach (low fractures and distal anatomical plates). The plate was slipped into the submuscular extraperiosteal position under fluoroscopic guidance. Reduction was always attempted indirectly by fluoroscopically guided external manoeuvres: traction along the axis and a support cushion for installation on a standard table or traction on the orthopedic table. If reduction was incomplete perioperative technical tricks could be used [2]. For example, the anatomical shape of distal femoral plates and the parallel epiphyseal screws make it possible to place the plate in an ideal position to be used as a "fracture reduction mold". Other tricks can be used when necessary: intrafocal pinning to reduce translation or a sagittal or frontal displacement but also a bone to plate lag screw. These fixations were designed to reinforce the implant already in place avoiding peaks of strain in an area of mechanical weakness between the femoral implant and the plate fixation (Fig. 1). The mechanical specifications for these systems are precise to allow post-operative weight bearing up to the pain threshold [2] but certain criteria must be fulfilled:

- 1) the fracture should be extra-articular;
- 2) fixation should be obtained with locking screws which should always be bicortical in outside areas of the femur where an implant is present in the femoral canal;



**Figure 1** A: Type C Vancouver fracture on THA with a cemented stem. B: internal fixation with a locking distal femoral plate after 1 year of follow-up. Note the bridging of the femoral stem to avoid peaks of strain between the two implants.

- 3) whenever possible, screws should be bicortical across along the femoral stem when the space taken up by the implant components permits, otherwise screws with flat ends provide the best possible fixation across along the femoral stem;
- 4) the system should be long, with at least five holes above the fracture zone and free holes and locking screws should be alternated for better absorption and distribution of strains along the plate (Fig. 2 and 3);
- 5) if screw fixation does not seem to be stable in the periprosthetic area, wire cerclage reinforcement can be used to resist the forces of plate pull out. The elasticity of titanium makes it possible to safely solicit the fracture site;
- 6) finally, patients should be sufficiently autonomous with a Parker score of at least 4.

Plate placement by mini-invasive surgery preserves the fracture hematoma and vascularisation, allowing immediate weight-bearing if these 6 conditions are met. The amount of osteoporosis is does not limit weight bearing as long as plate fixation criteria are met.

#### Method of evaluation

The clinical results were evaluated by the Parker score [3]. Indeed in this elderly population, the prognosis is in relation to patient morbidity-mortality and loss of autonomy. Radiologically, union was considered to be successful when at

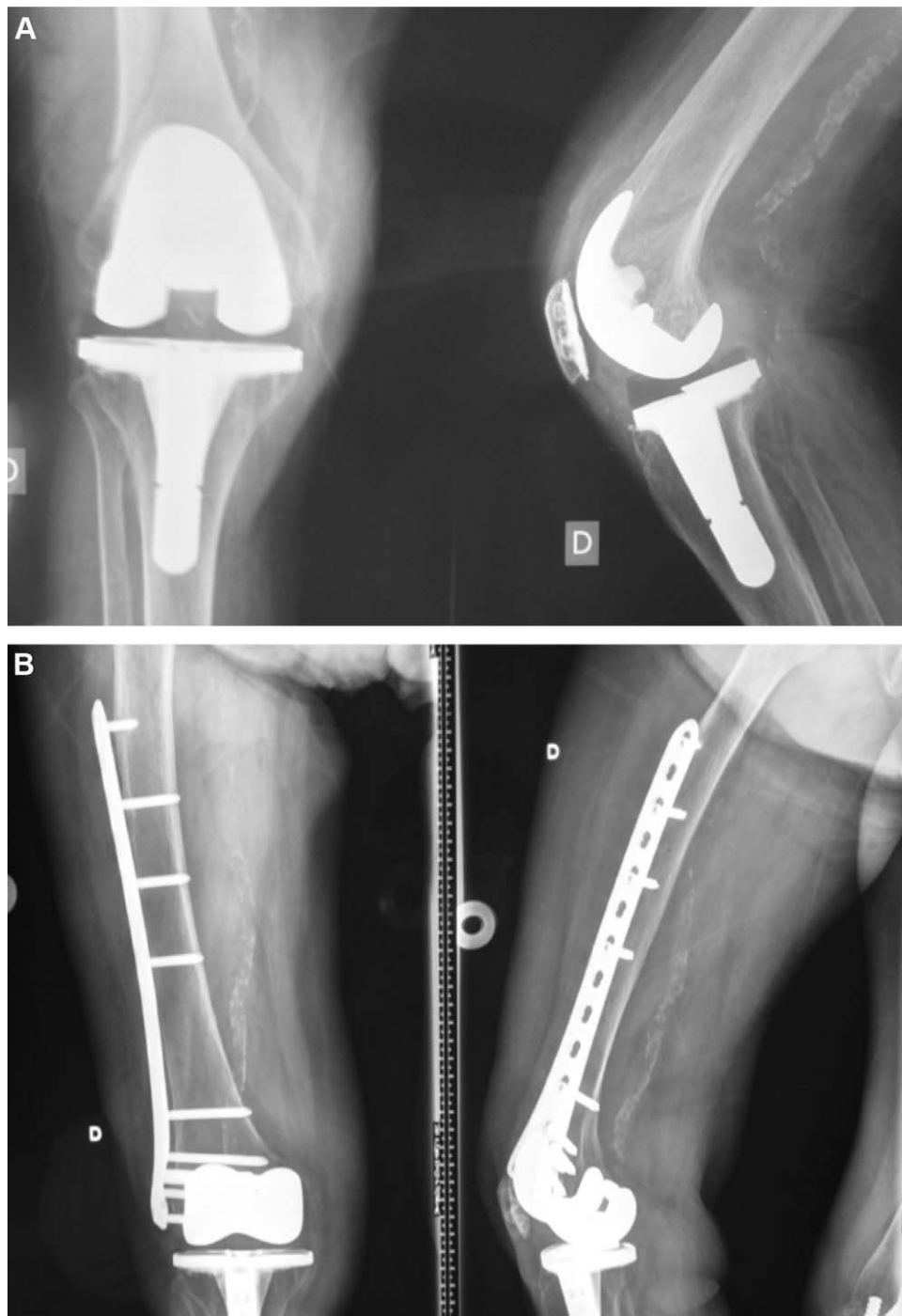
least two cortices were solid. The axes were defined radiologically in the immediate postoperative period and during follow-up with misalignment considered to be any axial deviation above  $5^\circ$  whatever the plane.

The pre- and postoperative Parker scores were compared in follow-up patients. The hypothesis was tested statistically,  $P < 0.05$  was considered to be significant. Because 30 patients were followed-up, the mean pre- and postoperative Parker scores were determined by the Student-t test and the medians and confidence intervals were identified.

#### Results

One patient in whom only radioclinical data during hospitalization were available was lost to follow-up. There was one early failure 3 days after surgery so that the surgical technique was changed and seven patients died including four who had been followed-up long enough (24, 40, 43 and 67 months) to be included in the study. The results are based on a cohort of 30 patients and 31 fractures with a mean follow-up of 26 months (6-67 months).

A mini-invasive surgical approach was used in 26 cases (72%), the mini-invasive approach was changed in eight cases to raise a muscular interposition ( $n=4$ ), for cement interposition ( $n=2$ ) and for placement of wire cerclage ( $n=2$ ), while the surgeon decided to perform conventional open surgery in two cases for no particular reason. The patient underwent surgery on a traction table in 21 cases and on a standard operating table in 15. Installation did not seem to



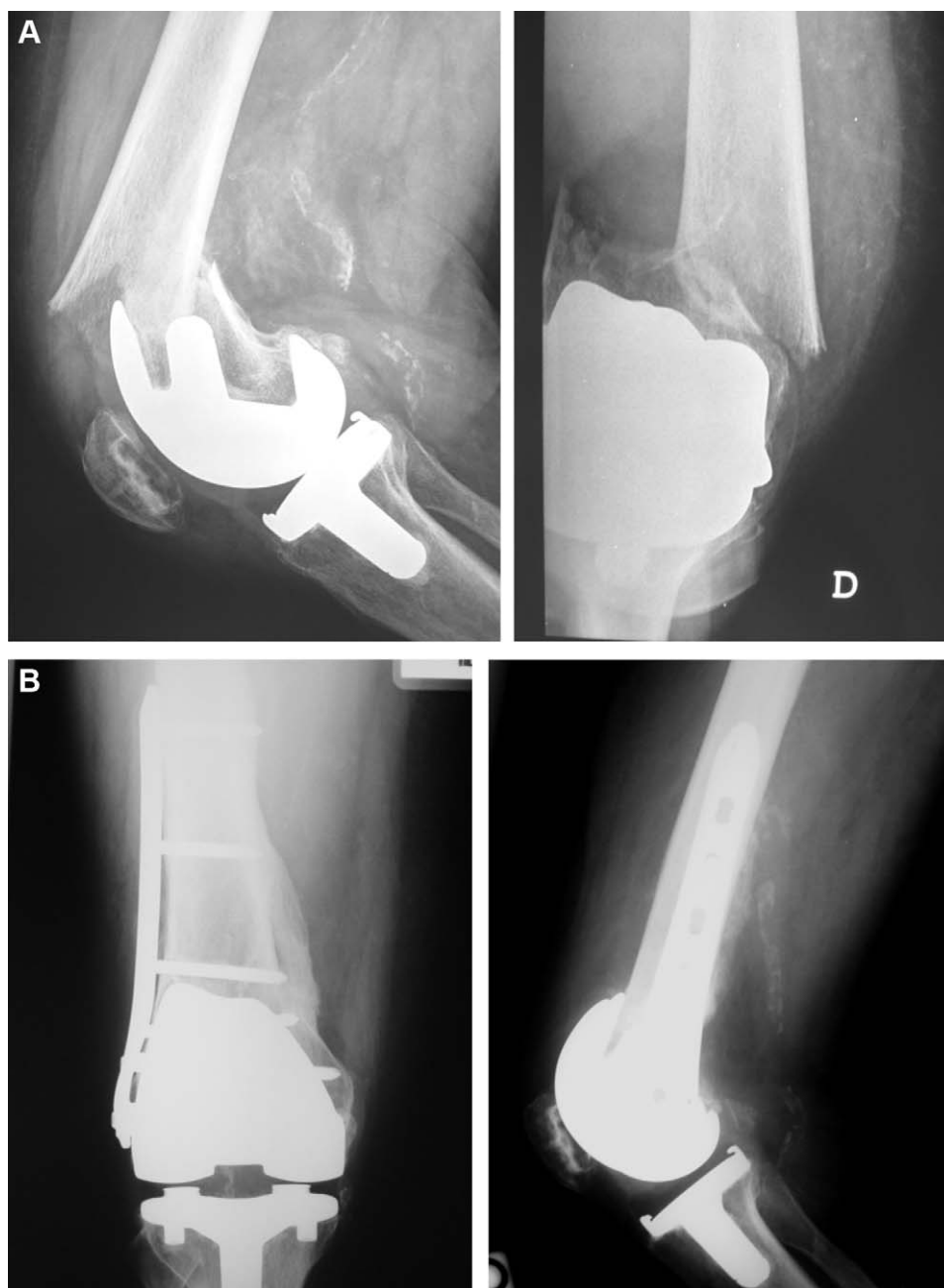
**Figure 2** A: long oblique type B–SOFCOT periprosthetic fracture on TKA. B: internal fixation with a long distal femoral plate, with well spaced locking screw for better distribution of strains 18 months after surgery.

influence the surgical approach used or a change in surgical approach, there were four converted surgical approaches on the standard table and four on the orthopedic table. A distal anatomical plate was used in 27 cases and a diaphyseal anatomical plate in nine cases.

Postoperative rehabilitation included free weight bearing by the patient until pain was felt in 20 cases, partial weight-bearing (20kg) for 6 weeks in three cases and walking without weight for 6 weeks in 13 patients with autonomy of three or less on the Parker scale. [3]. Weight bearing was

allowed as long as mechanical criteria were met and the preoperative level of autonomy was sufficient ( $n=20$ ). The three cases of “partial weight bearing” were prescribed in cases where the mechanical criteria were not met. The cases of “non weight bearing” corresponded to our early experience with internal fixation of periprosthetic fractures by locking plate or in patients whose autonomy was three or less on the Parker score.

At the final follow-up, the mean autonomy of patients on the Parker score [3] was 4.3 (0–9). The mean preoperative



**Figure 3** A: transverse supracondylar periprosthetic SOFCOT type B fracture on (TKA). B: another example of internal fixation with an distal anatomical femoral plate with spaced locking screws, 2 years after surgery.

Parker score for the entire series was 5.25 (0–9) and the preoperative Parker score of the 30 patients who were followed-up was 5.2 (0–9). The Parker scores were compared in patients followed-up after surgery. The median preoperative and postoperative scores were 6 and 4 respectively with a standard deviation of 1.1 between the means, which was significant ( $P < 0.001$ ) with a 95% confidence interval of 0.4. Thus, there was a loss of autonomy between the pre- and postoperative periods in patients followed-up for a mean 26 months.

Union was achieved in all patients except one (97%). Pseudarthrosis was confirmed in this patient by CT scan and was not treated due to the patient's comorbidities

and general condition. Misalignment of more than  $5^\circ$  was observed in five cases: one valgus ( $10^\circ$ ), one varus ( $7^\circ$ ), two recurvatum ( $6^\circ$ ), one mixed (varus  $7^\circ$  and recurvatum  $6^\circ$ ). Comparison of the first postoperative X-ray and those obtained after union shows that alignment was not influenced by early weight bearing. Clinical examination did not reveal any rotation anomalies. No loosening of implants was identified in the final follow-up.

There were seven complications. Two infections: 6 weeks after surgery *staphylococcus aureus* hematogenous septic arthritis developed in the knee in one patient and was non operatively treated by means of antibiotics, and 3 weeks after surgery *staphylococcus aureus* and *E. Coli* infection

developed on the incision site and was treated by surgical draining and appropriate antibiotics. Two general cardiopulmonary complications developed (cardiac decompensation and pneumopathy) and three mechanical complications: a) two cases of early fixation failure 3 days and 3 weeks after surgery respectively. In the first case, the indication was incorrect and conservative internal fixation was performed on a type B3 Vancouver fracture. Revision surgery was performed and the femoral stem was changed. In the second case locking plate assembly on the interprosthetic fracture was mediocre. The device lacked stability: there were only a few monocortical screws, distal and proximal cerclage was performed on an incomplete reduction and a third medial mediadiaphyseal fragment was not stabilized; b) one case of plate breakage occurred six weeks after surgery due to poor distribution of the locking screws which were placed near the fracture line thus concentrating strain around the fracture. Revision of internal fixation was performed. We also observed plate deformation with an angle of 30° secondary to a fall 6 weeks after surgery, which was not considered as a complication. The plate was straightened by external manoeuvres. The outcome was satisfactory with union achieved 3 months after internal fixation with a residual varus of 15° presenting no clinical difficulty for the patient. No THA dislocations occurred during postoperative follow-up.

## Discussion

Our population is comparable to that found in the epidemiological data in the literature [6]: female patients a mean 75–80 years old presenting with a fracture of the femur around THA secondary to a low impact/energy trauma.

Traditionally, treatment of periprosthetic fractures at a distance from the implant (type C) and on an implant with stable fixation (type B1) is conservative [1,7–10]. Although there is no consensus on the choice of internal fixation, the development of locking plates has been a turning point in the management of these fractures. Most authors report good results and support the use of this material, however, others do not. In a basic study, Zdero et al. [11] concluded that resistance was better with internal plate fixation without a locking screw and associated with an allograft. In a series of 14 periprosthetic type B1 fractures Buttaro et al. [12] reported six mechanical failures (43%) with a locking plate system and concluded that there were no advantages to this system. However, results of this series must be interpreted with caution because the surgical approach was open rather than mini-invasive so that internal fixation was no longer biological. Like other authors, [7,8,13–16] our study confirmed the advantage of early treatment with a locking plate system by a mini-invasive surgical approach in the treatment of femoral fractures on implants [2]. Stability of the device on fragile osteoporotic bone is essential for success [13,17,18] and the advanced age of our population, as well as the low rate of mechanical complications in our series seems to confirm the stability of this system.

The results of our study suggest that the prognosis for these periprosthetic femoral fractures is similar to that for hip fractures in elderly patients, with a revision and mortality rate of 20% in our series. We attempted to optimize

management of these patients by obtaining more rapid functional recovery to reduce morbidity-mortality as in the treatment of proximal femur fractures. The second necessity in this population of elderly patients is technical: immediate results should be obtained with no possibility of a second chance for surgical treatment. Locking plates associated with mini-invasive surgery seem to satisfy this requirement. Internal fixation by mini-invasive approach associates the advantages of closed reduction with preservation of the hematoma and periosteal vascularisation, and primary stability independent of the friction effect [7,8,13–16]. Unlike locked nailing this association helps obtain satisfactory union favoring development of a high quality callus [18–20]. Associating mini-invasive surgery with a locking plate system allows the patient to place weight on the leg as long as mechanical criteria are met, which was the case in 20 of the patients the current series [2]. This included 26 cases (72%) of mini-invasive surgery alone and eight cases of transformation (22%) of the mini-invasive approach. Our results confirm the feasibility of mini-invasive surgery in the treatment of periprosthetic fractures. After only 26 months of follow-up, we observed a reduction in autonomy, however this is expected because of the age of the population. The most relevant element was the possibility of rapid recovery of walking, which was confirmed by the absence of complications related to the decubitus position and the very low rate of general morbidity reported in this series.

There are an increasing number of series describing the treatment of periprosthetic fractures with a locking plate system [7–10,12,14–17,21–24]. Certain report mechanical failures due to material defects: three broken screws in 59 cases (5%) [7], 2/16 cases (12.5%) of plate breakage [8], three broken plates and three cases of plate pull out and loss of fixation out of 14 cases (43%) [12], 1/12 cases (8.5%) of loss of fixation and plate pull out [21], 1/24 cases (4%) of loss of fixation and plate pull out [23]. There were three cases of mechanical failure (8.5%) in our series: two cases of loss of fixation and one plate breakage, which can be explained by technical errors including incorrect indication and poor quality internal fixation assembly. Recent data in the fundamental literature show that the quality of locking plate devices can be improved and resistance to strain increased. Like Dougherty et al. [25], we advise the systematic use of bicortical screws at a distance from and around the implant whenever possible. The report by Button et al. [26] confirms this notion because they describe two cases of gradual displacement of the proximal plate attached by unicortical screws out of four cases of mechanical failure of distal femoral plates. To obtain more stable, homogenous fixation, Ahmad et al. [27] concluded that the device should be close to the bone. They concluded that a distance of less than 2 mm results in maximum resistance to compression and rotation, while more than 5 mm results in significant plastic deformation of steel, with a risk of plate breakage with titanium. LCP plates have holes that make it possible to use an “internal fixation”, “compression” or “mixed” system [28]. The “internal fixation” system is more stable under axial compression but with less plastic deformation while the “compression system” has better resistance to so that Stoffel et al. [28] recommend the use of a “mixed” system. Bottlang et al. [29] suggest using a standard screw

at the end of the plate to limit strain and avoid the risk of fatigue fracture by increasing resistance during flexion without affecting resistance to compression or rotation. Finally, for Wilkens et al. [30], the use of polyaxial locking screws increases resistance to compression, rotation, as well as the risk of breakage and results in less significant plastic deformation during cyclic axial loading.

## Conclusion

This study suggests that mini-invasive surgery can be indicated for fractures around non-loosened on prostheses good clinical and radiological results and that locking plates are well adapted to the treatment of these fractures. Indications must be respected for the success of this approach. The locking plate system makes early postoperative weight bearing possible as long as correct mechanical assembly is combined with a mini-invasive surgical approach to preserve the hematoma, which is an advantage in this elderly population to improve the rate of union.

## Disclosure of interest

ME and PA: occasional consultation for Synthès.  
YA, ADM, BM, FB: no conflict of interest.

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