RESEARCH ARTICLE

Locking Attachment Plate for the Surgical Treatment of Periprosthetic and Periimplant Fractures: Long-Term Follow-Up

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Abstract

Objectives: The surgical management of periprosthetic fractures (PPF) and periimplant fractures (PIF) can be challenging. The locking attachment plate (LAP) was proposed in recent years for the osteosynthesis of such fractures. The aim of this study was to assess the experience of a third-level hospital with LAP for the treatment of PPF and PIF, and analyse the clinical outcomes.

Methods: Data were prospectively collected and analysed from all patients whose PPF/PIF was treated surgically with LAP in a third-level hospital from June 2018 to June 2022. All fractures were postoperative low-energy femur fractures. The minimum follow-up period was six months.

Results: Thirty-eight patients (31 women) met the eligibility criteria. The mean age was 86.3 years. The median time until surgery was 4 days. A mean of 3.61 screws were used for each LAP. The mean femur plate length was 14 holes, and the mean working length 7.1 holes. The median hospital stay was nine days. The mean follow-up was 19.56 months. At one month, 12 patients tolerated partial weight-bearing. Five patients walked independently indoors. One patient had died and seven patients were readmitted. At six months, six more patients had died. Fifteen patients tolerated full weight-bearing (FWB). Nine patients walked independently indoors, six outdoors. Twenty-five patients reached fracture consolidation without malalignment. Nine patients were readmitted. At 12 months, another patient had died. Seventeen patients tolerated FWB. Eleven patients walked independently indoors, six outdoors. Twenty-five patients achieved fracture consolidation without malalignment. Five patients were readmitted. Fourteen patients crossed the two-year postoperative threshold. All achieved fracture consolidation. Two patients passed the 4-year postoperative milestone.

Conclusion: The clinical results of patients whose PPF or PIF was treated with the LAP are promising. This fixation method is a viable option to be considered when planning surgery for such fractures.

Level of evidence: III

Keywords: Locking attachment plate, Open reduction and internal fixation, Osteosynthesis, Periimplant fracture, Periprosthetic fracture, Results

Introduction

Periprosthetic fractures (PPF) and periimplant fractures (PIF) are fractures that occur around an implanted orthopaedic prosthesis or osteosynthesis implant, respectively. They are commonly considered fragility fractures, as they tend to occur in the context of osteoporotic bone quality. Depending on when they occur, they can be classified as intraoperative or postoperative. The incidence of these fractures varies greatly by series,

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prosthesis/implant site, and whether primary or revision arthroplasty is involved. It has been reported from 0.1 percent up to 18 percent in some series and is rapidly increasing in developed countries,[1-3] to the point that it has recently been described as "the next epidemic of fragility fractures" by Bottle and colleagues.[2] Some of the factors related to this increase are the aging population, the increasing number of total hip arthroplasties (THA), total knee arthroplasties (TKA), and intramedullary nails, as well as the growing trend toward uncemented femoral stem fixation in primary THA.[4-6]

Surgical management of PPF and PIF can be technically challenging because of the high-risk profile of patients and the coexistence of fracture, prosthesis/implant, and other factors such as the cement used to fix the femoral component and poor bone quality. Treatment has evolved from non-operative measures such as traction, which has shown poor results, to surgery, which offers great advantages such as early mobilisation and reduced hospital stay, and has been associated with a lower overall mortality rate, although selection bias plays an important role in this association.[7-9] Open reduction and internal fixation (ORIF) can be approached in many ways [10] and is classically an indication in fractures associated with a well-fixed stem in which revision arthroplasty is not required, although this concept has recently been questioned.[11,12]

In recent years, the Locking Attachment Plate (LAP) system has been proposed as an innovative surgical device that allows the placement of bicortical screws next to the prosthesis stem or osteosynthesis implant and is useful in the context of ORIF of such fractures. Despite its growing popularity, not much literature has been published to date. The aim of this study is to evaluate the experience of a third-level hospital in a European Metropolitan Area with LAP for the treatment of PPF and PIF, and analyse the clinical outcomes.

Materials and Methods

In this prospective observational study, we collected and analysed data from all patients whose PPF/PIF was surgically treated with LAP in a third-level hospital, from June 2018 to June 2022. Inclusion criteria were 1) PPF and/or PIF undergoing ORIF, 2) securing the healing of a fracture near a new-implanted hardware, and 3) the use of LAP for surgical treatment. The exclusion criteria for inclusion in the analysis were 1) a follow-up period of less than six months unless the patient had died, and 2) radiological evidence of loosening of the prosthetic stem requiring revision surgery at the time of fracture.

Data were collected from each patient according to the following clusters: demographic (sex, age, domicile), baseline clinical (Barthel Index – a measure of independence status, Pfeiffer test score – a measure of cognitive status, Functional Ambulation Category score – a measure of mobility status, American Society of Anesthesiologists (ASA) score – a measure of anesthesiology risk, Charlson comorbidity Index – a measure of comorbidity status, antiresorptive, anticoagulant, and antiaggregant drugs), radiologic (type of fracture and classification, type of implant or prosthesis present and time since its placement, presence of prior loosening or infection, description of the stem, and approach), surgical (time to surgery, number of LAP plates used, average number of screws used in LAP plates, working length), and postoperative (hemoglobin loss, indications for postoperative mobilization, and clinical or surgical complications).

During the follow-up, data were collected regarding domicile, functional status, radiological status (consolidation, alignment, loosening, failure), and the presence of hospitalisations due to medical or surgical causes, with their description. Postoperative follow-up checkpoints were established in time at one month, six months, one year, two years, and four years. All patients signed the informed consent for adherence to the study, and the project was approved by the ethics committee of the hospital.

The statistical analyses were performed using the Statistical Package for the Social Sciences software (IBM® SPSS® Statistics, Version 25.0.0; IBM Corp., Armonk, N.Y., USA) and R (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/). The distribution of the quantitative variables was tested using the Kolmogorov-Smirnov test. The quantitative variables are reported as means and standard deviations (±SD) or medians and quartiles (Q1-Q3), according to the characteristics of each variable's distribution. The qualitative variables are reported as sample size and corresponding relative frequency (%).

Results

Thirty-eight patients met the eligibility criteria. The sample consisted mainly of women (F=31, 81.6%). The mean age was 86.3 years (±8.84). All fractures were postoperative low-energy (ground-level falls) femur fractures. At the time of the fracture, the median Barthel index was 77.5 points (58.75-91.25), the median Functional Ambulation Category (FAC) test result was 3 points (2-4) and the median Pfeiffer test score was 7 (3-9.25). Twelve patients (31.5%) were taking antiresorptive drugs prior to fracture. The median Charlson comorbidity index was 6 (4-7). At the time of admission to our hospital, 22 patients (57.9%) lived at home, 13 (34.2%) lived in a nursing home, and 3 (7.9%) were admitted to other hospitals. The median time from fracture to surgery was four days (3-5). In one patient, surgery was performed 93 days after the fracture because conservative treatment had been attempted.

In all but two patients, four-hole LAPs were used. In 20 patients (52.6%) two LAPs were used, in 8 patients (21.1%) one LAP was used, in 9 patients (23.7%) three LAPs were used, and one patient (2.6%) received 4 LAPs. An average of 3.61 (±0.68) screws were used in each LAP. The median femoral plate length was 14 (12-16) holes. The mean working length was 7.1 (±2.6) holes. This shows a preference for elastic over rigid constructions. All LAPs were placed on a Variable Angle-Low Contact Plate (VA-LCP condylar plate) at the stem/nail level [Figure 1]. Monocortical screws and cerclage wires were not employed in any case. In the first routine postoperative laboratory examination, performed 24 hours after surgery, the median hemoglobin loss was 1.5 mg/L (0.38-2.15). Twenty-eight patients (73.7%) required intra- or postoperative blood transfusion. On the first postoperative

day, twenty-two patients (57.9%) were placed in a sitting position. We identified recommendations for weight-bearing during the first six weeks postoperatively based on fracture pattern and fixation. During hospital stay, nineteen (50%) patients had medical complications other than blood loss during the hospitalisation, and all were successfully treated. [Table 1] lists the nature of the above complications. The median length of hospital stay was 9 (7-12.75) days. Upon discharge from the hospital, fifteen patients (39.5%) went home, twenty (52.6%) went to a nursing home, and three (7.9%) were transferred to another hospital [Figure 2]. Nineteen patients (50%) had antiresorptive therapy in the discharge report.

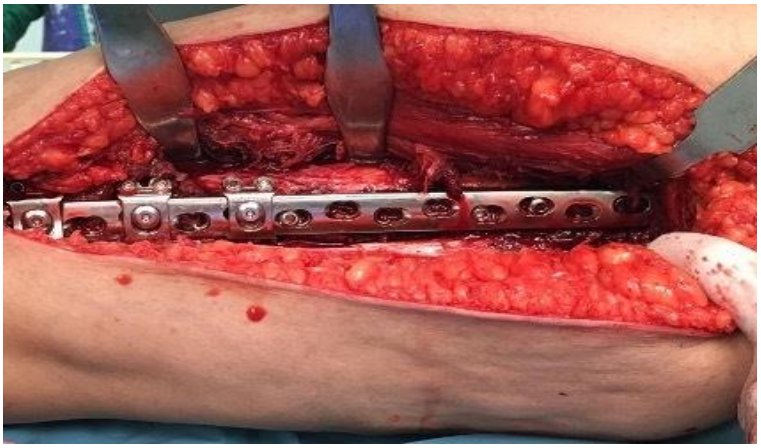

Figure 1. Intraoperative view of the locking attachment plate (LAP) system on a variable angle-locking compression plate

Table 1. Patients who had medical complications during hospital stay. Each line represents a different patient

1.	LRTI
2.	AKI
3.	Pulmonary embolism, ADHF, lower GI bleeding
4.	ADHF with acute respiratory failure and AKI
5.	AKI, lower GI bleeding, drug toxicoderma
6.	AKI, metamizole-associated maculopapular exanthema, paralytic ileus
7.	AKI
8.	UTI
9.	Delirium
10.	ADHF, bronchoaspiration, pressure ulcer, dysphagia, sepsis, delirium
11.	ADHF, AKI, acute urinary retention
12.	Subdural hematoma
13.	Pressure ulcer, COVID-19, persistent wound drainage
14.	ADHF with generalized anasarca
15.	ADHF, AKI, LRTI, UTI bacteremia
16.	Active arterial bleeding without objective focus for embolization
17.	LRTI, ADHF, AKI, COVID-19
18.	Acute urinary retention
19.	AKI

LRTI = lower respiratory tract infection; AKI = acute kidney injury; ADHF = acute decompensated heart failure; GI = gastrointestinal; UTI = urinary tract infection

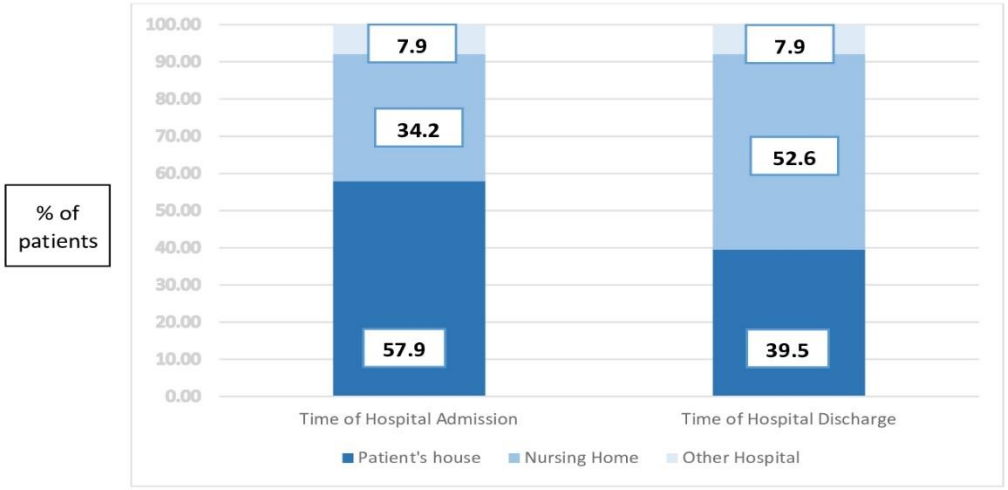

Figure 2. Institutions involved in patients' care

We analyzed a total of 39 fractures in 38 patients. One patient held two bilateral peri-prosthetic femur fractures in the same traumatic act [Figure 3]. Of the 39 fractures, twenty-four (61.5%) were PPF, twelve (30.8%) PIF, two (5.1%) inter-implant fractures [Figures 4 and 5], and another patient (2.6%) presented a femoral neck fracture in combination with an intercondylar fracture [Figure 6].

Among the 24 PPFs, 21 occurred in relation to hip arthroplasties, two near the stem of hinged TKA, and one in the proximity of a stemless femoral component of TKA. The median time from arthroplasty to PPF was 26.65 (4-87.81) months. Of the 21 hip arthroplasties, thirteen (61.9%) were THA and eight (38.1%) were hip hemiarthroplasties (HHA). All femoral components had a stem. Regarding stem fixation, twelve out of twenty-one (57.1%) were cemented, while the remaining nine (42.9%) were uncemented. All HHAs were cemented. Regarding fracture pattern, fifteen (71.4%) fractures were classified as Vancouver C and six (28.6%) as Vancouver B1.

Among the PIFs, all implants were cephalomedullary nails. The median time from osteosynthesis to PIF was 28.65 (1.83-51) months. In two cases, hardware removal was necessary to achieve optimal positioning of the implants used for PIF treatment. Hardware removal was possible because the patients had already achieved healing of the intertrochanteric fracture.

The mean follow-up period after surgery was 19.56 (±14.06) months.

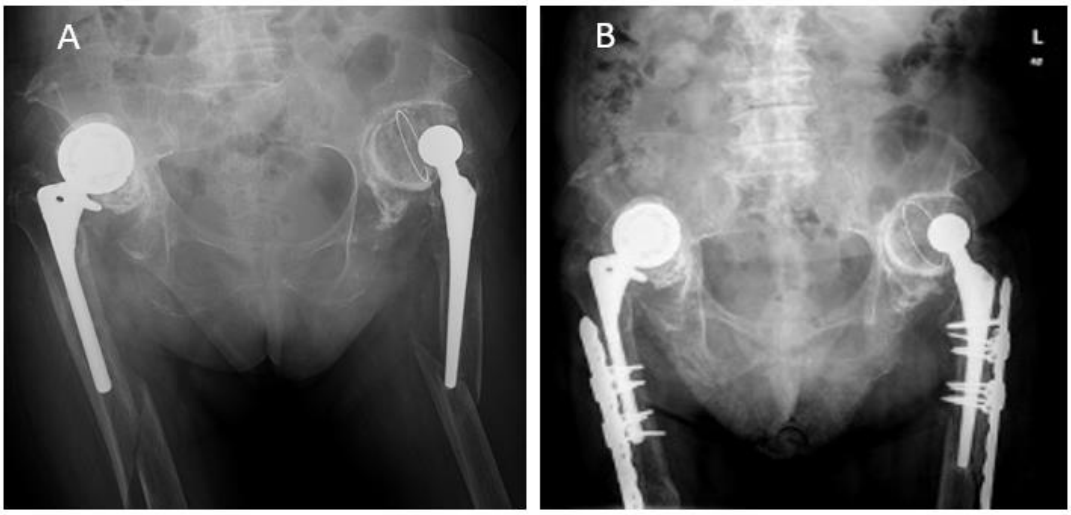

Figure 3 (A-B). Bilateral periprosthetic femur fracture (A), treated operatively in the same day (B)

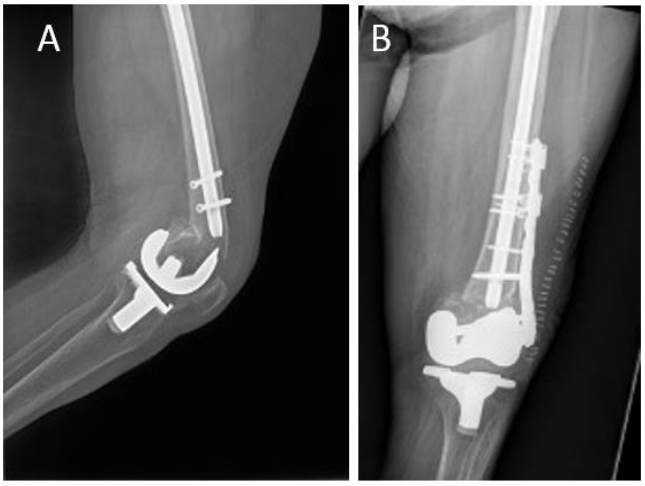

Figure 4 (A-B). Fracture between a posterior-stabilized total knee arthroplasty and a long cephalomedullary nail (A), fixed (B)

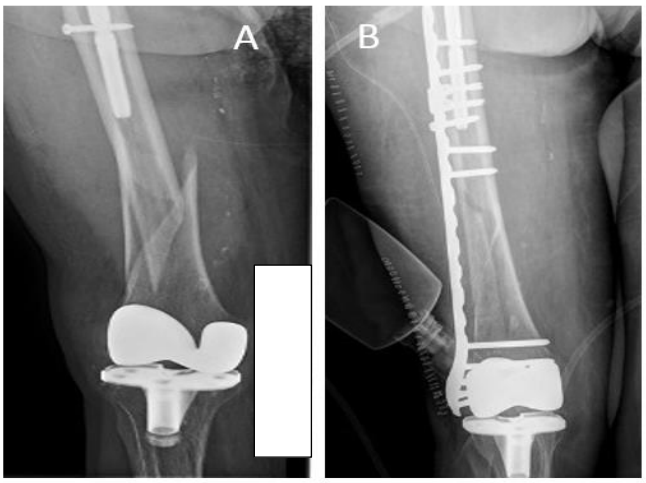

Figure 5 (A-B). Fracture between a posterior-stabilized total knee arthroplasty and a short cephalomedullary nail (A), fixed (B)

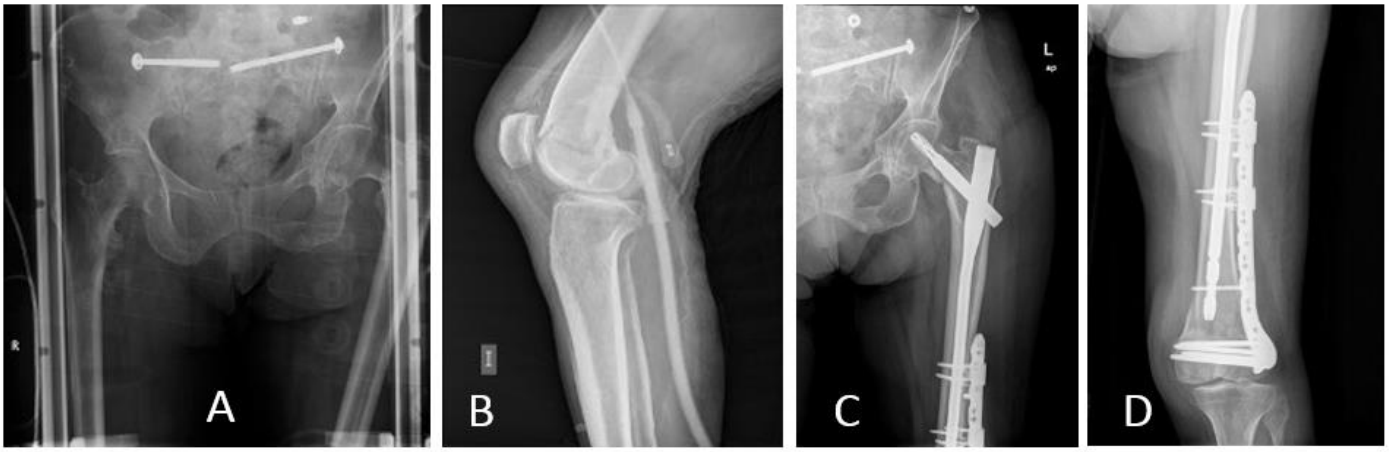

Figure 6 (A-D). Polytrauma patient with left femoral neck fracture (A) in combination with an intercondylar fracture (B), treated with a long cephalomedullary nail (C) and a locking compression plate with two locking attachment plates (D)

An overview of the follow-up can be visualized in [Table 2]. This can be used as a reference guide to the details listed in the following paragraphs.

At one month of follow-up, 12 patients were tolerating partial weight-bearing with the help of crutches, and five patients were able to walk independently at home. One patient had died, being in another hospital with major medical complications (decompensated heart failure, bronchoaspiration in the context of dysphagia, and urinary sepsis), and was unable to stand at any time. Two patients were readmitted for superficial wound infection, treated in both cases successfully with oral antibiotic therapy. Five other patients were readmitted for causes unrelated to the fracture (urogenital disease, acute renal failure in two cases, cardiac and respiratory failure, and COVID-19).

At the six-month follow-up, six other patients had died, one of whom had achieved fracture healing before dying. None of them died directly from problems related to the surgery. A total of fifteen patients tolerated the full weight-bearing, with nine patients able to walk independently at home and six patients able to walk outdoors a short distance from the home. A total of twenty-five patients achieved radiological results of optimal fracture consolidation, with no malalignment or secondary displacement. Nine patients were readmitted. The first had a soft tissue infection at the wound site that required surgery for debridement. The second, suffering from class III obesity, had a ruptured plate and underwent surgery for hardware removal and fixation with a thicker femoral plate and two four-hole LAPs with four screws each, with excellent results to date [Figure 7]. The third suffered an ipsilateral tibial plateau fracture and underwent ORIF with satisfactory clinical results. The fourth was readmitted for chronic fistulised surgical wound infection related to osteosynthesis, with isolation of pseudomonas in the surgical act of lavage and

debridement. This patient suffered progressive deterioration of renal function in the postoperative period, leading to multi-organ failure and eventually to the patient's death. The remainder were readmitted for reasons unrelated to the fracture (transmetatarsal amputation of the big toe for vascular causes, acute renal failure, pneumonia, and two cases of COVID-19).

Table 2. Follow-up overview. Data are not presented in a cumulative fashion. Data about fracture consolidation, number of reoperations and number of readmissions are extracted from patients that reached alive each follow-up time check (N= number)

	1 month	6 months	1 year	2 years	3 years	4 years
N of patients	37	31	26	14	6	2
N of deaths	1	6	1	0	0	0
Not reached follow-up (alive)	0	0	4	16	24	28
Fracture consolidation	0	25	25	14	6	2
N of reoperations	0	4	0	0	0	0
N of readmissions	7	9	5	4	3	1

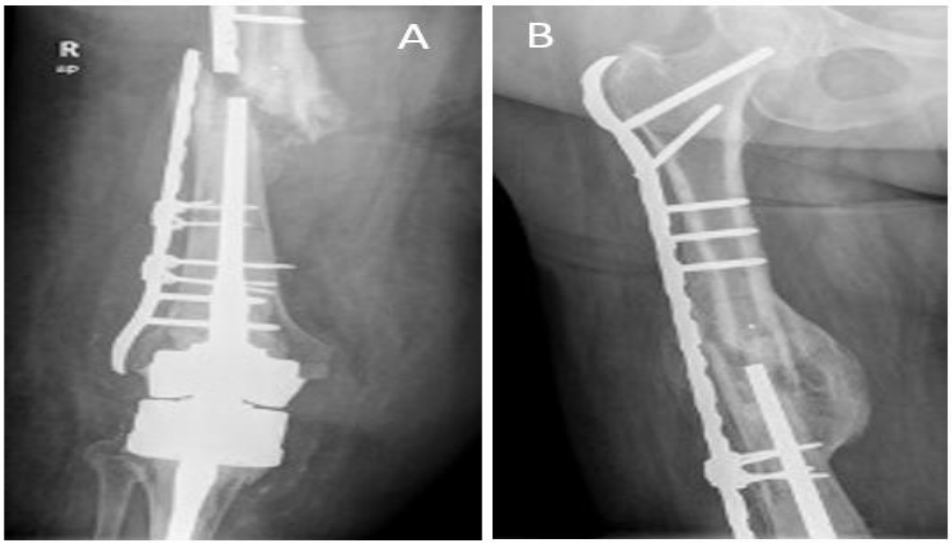

Figure 7 (A-B). Ruptured plate (A) that underwent surgery for removal and fixation with a thicker plate and locking attachment plate (B)

At the 12-month follow-up, another patient died from causes unrelated to the fracture. Four patients have not yet reached the 12-month follow-up, but all four have already achieved fracture healing and are tolerating full weight-bearing without implant failure. Of the twenty-six patients with results at one-year follow-up, a total of seventeen patients tolerated full bearing. Eleven patients were able to walk independently in the home and six were able to walk outdoors within a short distance of the home. A total of twenty-five patients achieved radiologic fracture consolidation with no findings of malalignment in any plane on plain radiography. Five patients were readmitted for causes unrelated to the fracture (urinary tract infection, traumatic brain injury, overdose drug intoxication, benign prostate hyperplasia surgery, and COVID-19).

Fourteen patients crossed the two-year postoperative threshold. All had achieved fracture consolidation. Ten tolerated full weight-bearing, the rest required assistance with ambulation. Four patients habitually walked

outdoors, the remainder did not habitually go outside. Eight lived at home, four lived in a nursing home, and two were hospitalized. A total of four patients were hospitalised for causes unrelated to the fracture (heart failure, subarachnoid hemorrhage, low urinary infection, and medical overdose with autolytic purposes).

Six patients reached the three-year postoperative term. Of these, only one patient habitually walked outside his home. One patient lived in a nursing home. Two patients were hospitalized for pneumonia and one for cholecystitis.

Two patients passed the 4-year postoperative milestone. One lives in a nursing home, was hospitalized for heart failure and hardly walks, while the other lives at home where he walks without assistance, and does not usually leave the house.

Discussion

Today, the incidence of PPF and PIF is increasing. In the coming years, the magnitude of this phenomenon may represent a major soft spot in the field of trauma, due to the fragile state of the population affected by these fractures and the economic burden that these pathologies entail. As far as the overall survival is concerned, we had 8 deaths among 38 patients. This is in line with previously reported data in the literature.[3] Indeed, despite the accuracy of the available grading systems and the technical advances of recent years, the surgical management of these fractures remains one of the most challenging for an orthopaedic surgeon. It is of utmost importance to insist that, in addition to the fracture pattern, the frailty status of the population suffering from this type of fracture contributes significantly to worsening patients' clinical outcomes. Although surgical treatment of these fractures has been shown to reduce the length of hospital stay, they still have a significant economic impact from a societal perspective.[8,13] This is partly due to the needs of patients not only during hospitalisation but also after discharge, when a significant percentage of patients require support from public facilities other than the hospital, as outlined in [Figure 2]. That said, the present study is far from being an economic analysis on the subject, and more data would be needed for this purpose.

In the present case series, Vancouver B2-type periprosthetic fractures are not included. This is because, in the hospitals where the surgeries were performed, fractures with prosthetic stem loosening are dealt with by a different orthopedic unit, which is in charge of component replacement and is not used to using osteosynthesis plates. The LAP plate was preferred over cerclage wire in all patients, as it demonstrates a more respectful behavior toward the periosteal vascularization of the femoral diaphysis. The advantages of locking plates have been demonstrated in multiple anatomical districts.[14] as we can see from the results of our series, in no case was there a biomechanical collapse of the LAP/VA-LCP/bone construct. Although there is a case of condylar plate rupture, there is no witnessed tear of the LAP seal to the cortical bone around the prosthetic stems or osteosynthesis implants in any case. This, together with the decent functional results obtained on a population fragile in age and characteristics, and suffering such a life-changing event, confirms that the LAP system is a useful resource at the time of surgical planning of such fractures.

This study has some limitations that need to be acknowledged. First, the number of patients is limited. Second, the outcomes were not analyzed in relationship to the fracture location and classification. Third, the results have not been compared with other methods of fixation.

However, the outcomes are promising, although further clinical studies and higher evidence level are needed to compare the results of this system with other fixation constructs.

Conclusion

The clinical results of patients whose PPF or PIF was treated with the LAP plating system are promising. Despite, there is still a high morbidity and mortality following periprosthetic fractures. Although further studies are needed, the results of this study suggest that this fixation method is a viable option to be considered when planning surgery for such fractures.

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