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Original article

Interprosthetic femoral fractures: Morbidity and mortality in a retrospective, multicenter study

Paul Bonnevialle[a,*], Pierre-Sylvain Marcheix[b], Xavier Nicolau[c], Marine Arboucalot[a], Marie Lebaron[d], Christophe Chantelot[e], Didier Mainard[f], Matthieu Ehlinger[c], members of the Getraum[g]

[a] Département universitaire d'orthopédie traumatologie, hôpital Pierre-Paul-Riquet, place Baylac, 31052 Toulouse, France
[b] Service de chirurgie orthopédique et de traumatologie, 2, avenue Martin-Luther-King, 87000 Limoges, France
[c] Service de chirurgie orthopédique et de traumatologie, hôpital de Hautepierre, hôpitaux universitaires de Strasbourg, 1, avenue Molière, 67098 Strasbourg, France
[d] Service de chirurgie orthopédique et de traumatologie, hôpital Nord, chemin des Bourrely, 13015 Marseille, France
[e] Service de chirurgie orthopédique et de traumatologie, place de Verdun, 59037 Lille, France
[f] Service de chirurgie orthopédique et de traumatologie, hôpital central, CHU de Nancy, 29, avenue de Lattre-de-Tassigny, 54000 Nancy, France
[g] Groupe d'étude en traumatologie [French Orthopedic Trauma Society], 56, rue Boissonade, 75014 Paris, France

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ABSTRACT

Introduction: Interprosthetic femoral fractures (IFF) are becoming more frequent; however they have not been the subject of many publications and the largest study on this topic includes only 30 cases. The complication rate and clinical outcomes have only been evaluated in small case series. This led us to conduct a retrospective, multicenter, observational study in IFF patients with at least 12 months' follow-up to (1) determine the mortality and morbidity (2) determine the clinical and radiological outcomes and (3) identify elements of the treatment indications.
Hypothesis: The morbidity and mortality rates will be comparable to those in recent studies on this topic.
Materials and methods: The study included 51 patients (49 women, 2 men) with a mean age of 82.8 ± 9.2 years [55–97], a mean Parker score of 4.9 ± 2.4 and a mean Katz score of 4.4 ± 1.4 who had suffered an IFF between 2009 and 2015. According to the SoFCOT modifications of the Vancouver classification, 30 fractures were interprosthetic in the shaft segment where there were no implants (19 double C and 11 type D (corresponding to a type C with less than two diaphysis widths between the extension stems of the hip and knee implants)) while 21 were periprosthetic, with 12 around the THA (11 B1 and 1 B3) and 9 around the TKA (8 B1 and 1 B3). One patient was treated conservatively with an external fixator but died the next day, 2 patients received a new total hip arthroplasty and 47 underwent plate fixation of their fracture (one patient was treated non-operatively because of poor medical condition).
Results: One patient was lost to follow-up, and nine died during the first 6 months. Six early surgical site complications occurred and 13 general ones. Within 1 year of the IFF, there were six mechanical complications, two surgical site infections and two cases of loosening. The mean follow-up was 27.6 ± 17.2 months. The mean time to union was 19.25 ± 8.8 weeks. The mean final Parker score was 3.37 ± 2.6 and the mean Katz score was 2.98 ± 1.8; both were significantly lower than the initial scores. Six patients died between months 12 and 50. The overall mortality at the final review was 31% (16/51) with a median survival of 3.45 years.
Discussion: Our hypothesis was not confirmed because the mortality and morbidity in our study were higher than in other published studies. In the six relevant studies identified, the surgical site infection rate was 12.3%, the major revision rate was 11.6% and the mortality rate was 6.5%. In our study, these values were 24%, 24% and 31%, respectively. These worse results may be explained by the very fragile nature of the studied population and the surgeons not following appropriate technical rules for fracture fixation.
Level of evidence: IV, Retrospective study.

* Corresponding author.
E-mail address: ventre.s@chu-toulouse.fr (P. Bonnevialle).

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1. Introduction

The large increase in the number of total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures combined with the increased life expectancy of patients had resulted in an increase in the number of periprosthetic femur fractures [1–3]. In 5% to 7% of cases, the femoral fracture is interprosthetic (IFF), which is defined as the fracture line being in the diaphysis between THA and TKA implants, or near implant but sparing the other, although each implant may be mechanically deficient [4–6]. This traumatic condition immediately causes a technical surgical fixation problem, which itself can negatively impact the mortality and morbidity.

Initially described by Dave [7] and in anecdotal clinical cases [8,9], the largest studies of IFF have highlighted the fixation and union challenges [10–19]. While two French studies have been published, the number of cases was relatively low [13,16]. This led members of the GETRAUM (French Orthopedic Trauma Society) to conduct a retrospective multicenter observational study on this topic. This study included IFF patients with at least 12 months' follow-up to (1) determine the mortality and morbidity, (2) determine the clinical and radiological outcomes and (3) identify elements of the treatment indications. We hypothesized that the morbidity and mortality rates will be comparable to those in recent studies on this topic.

2. Patients and methods

2.1. Inclusion and exclusion criteria

The inclusion criterion was a recent femur fracture in a leg on which THA and ipsilateral TKA had been first performed at one of six French teaching hospitals. Exclusion criteria were an arthroplasty performed in the context of bone tumor, pathological femur fracture, recurrent IFF or treatment of nonunion following the initial IFF.

2.2. Patient population

Between 2009 and December 2015, we identified 51 IFF cases for this study [Lille (n = 8), Limoges (n = 8), Nancy (n = 4), Marseille (n = 4), Strasbourg (n = 9), Toulouse (n = 18)]. The cohort consisted of 49 women and 2 men with a mean age of 82.8 ± 9.2 years [55–97]. Four patients were under 65 years of age, 13 were between 65 and 79 years of age, 22 were between 80 and 89 years of age, and 12 were more than 90. Forty patients lived at home at the time of the fracture (78%) while 11 were in a nursing home (22%). The ASA score [20] was 2 in 23 patients, 3 in 23 patients, and 4 in 5 patients. The mean Parker score [21] was 4.9 ± 2.4 and the mean Katz ADL score [22] was 4.4 ± 1.5.

The mean time elapsed between the hip arthroplasty procedure and IFF was 123 months ± 99 [4–396 months]. At the time of the IFF, 5 patients had a bipolar implant and 46 had a THA. These procedures had been performed for primary hip osteoarthritis in 36 patients, rheumatoid arthritis of the hip in 2 patients and proximal femur fracture in 13 patients. Among the THA cases, 7 implants had been previously revised due to loosening. Two of the bipolar implants were cemented and three were cementless. Of the 46 THA cases, 29 had cemented stems, 14 had cementless stems, 2 had locked revision stems and 1 had a long, cemented stem.

All of the knee implants were TKA. The mean time elapsed between the TKA procedure and IFF was 93.7 months ± 68.8 [1–276 months]. The TKA procedures had been performed for knee osteoarthritis in 45 cases, rheumatoid arthritis in 2 cases and fractures in 4 cases. The TKA was a primary implant in 44 cases and a revision implant in the 7 other cases (5 for loosening, 1 for fracture near implant and 1 for nonunion). Cemented implants were used in 36 cases and cementless ones in 15 cases. The patella had been resurfaced in 45 cases.

The IFF occurred in the distal third of the femur in 21 patients (41.2%), in the middle third in 20 patients (39.2%) and in the proximal third in 10 patients (19.6%). The fracture had a spiral pattern in 25 cases (49%), oblique in 15 cases (29.4%), transverse in 7 cases (13.7%) and comminuted in 4 cases (7.8%). The fracture was also defined based on its position relative to the THA and TKA implants. According to the SoFCOT classification [4] as modified by Soenen et al. [13], 30 fractures were in the diaphysis between the two implants (19 double C and 11 type D corresponding to a type C with less than two diaphysis widths between the extension stems of the hip and knee implants according to Soenen et al. [13]) while 21 fractures were periprosthetic, with 12 near the THA (11 B1 and 1 B3) and 9 near the TKA (8 B1 and 1 B3).

The surgical procedure was performed an average of 2.2 ± 2.2 days after the fracture; 26 patients (47%) were operated within 24 hours. Forty-seven patients underwent isolated fracture fixation without the implants being revised: 2 with standard plates, 40 with locking plates using a lateral approach that lifts the vastus lateralis and 5 with locking plates through a minimally invasive approach (Fig. 1). One patient was treated with an external fixator because of intraoperative damage to the femoral artery. Two patients had the THA revised to a long, modular cementless stem with multiple levels of wire cerclage. A quasi bed-ridden nonagenarian with major cardiovascular comorbidities could not undergo any anesthesia, thus was treated non-surgically with traction then bracing.

2.3. Assessment methods

Data was collected in a common anonymized spreadsheet used to capture standard demographic and epidemiology information, in particular the preoperative and postoperative ASA [20], Parker and Palmer [21], and Katz et al. [22] scores for patients above 65 years of age. The clinical and radiological assessments were done at the latest follow-up visit based on the patient's living situation and geriatric trauma scores. Fracture union was achieved when at least one cortex was continuous on the A/P and the lateral views. The quality of the reduction was deemed good when the deformity was less than 5° in any plane.

2.4. Statistical methods

All statistical tests were performed using the software, Statis (version 8.4.6, O. Méricq, Toulouse, France). Student's t-test was used to compare different mean values, while the Chi^2 test was used with independent qualitative variables when the sample size was more than 5. Fisher's exact test was used when the sample size was less than 5. Survival was calculated using the actuarial method. The significance level was set at 0.05.

3. Results

3.1. Complications and early deaths

The femoral artery was damaged during fracture reduction in one 85-year-old female patient (ASA 4, Parker 6, Katz 6); surgical repair was performed, and an external fixator was applied. This patient died the next day. Postoperatively, 21 patients (42%) returned home and 39 patients (58%) went to a nursing home. The early outcome is known for 49 patients (one patient lost to follow-up upon discharge).

Nine deaths occurred in the first 6 months, which is an 18.4% early mortality rate: all of these patients were at least 80 years of

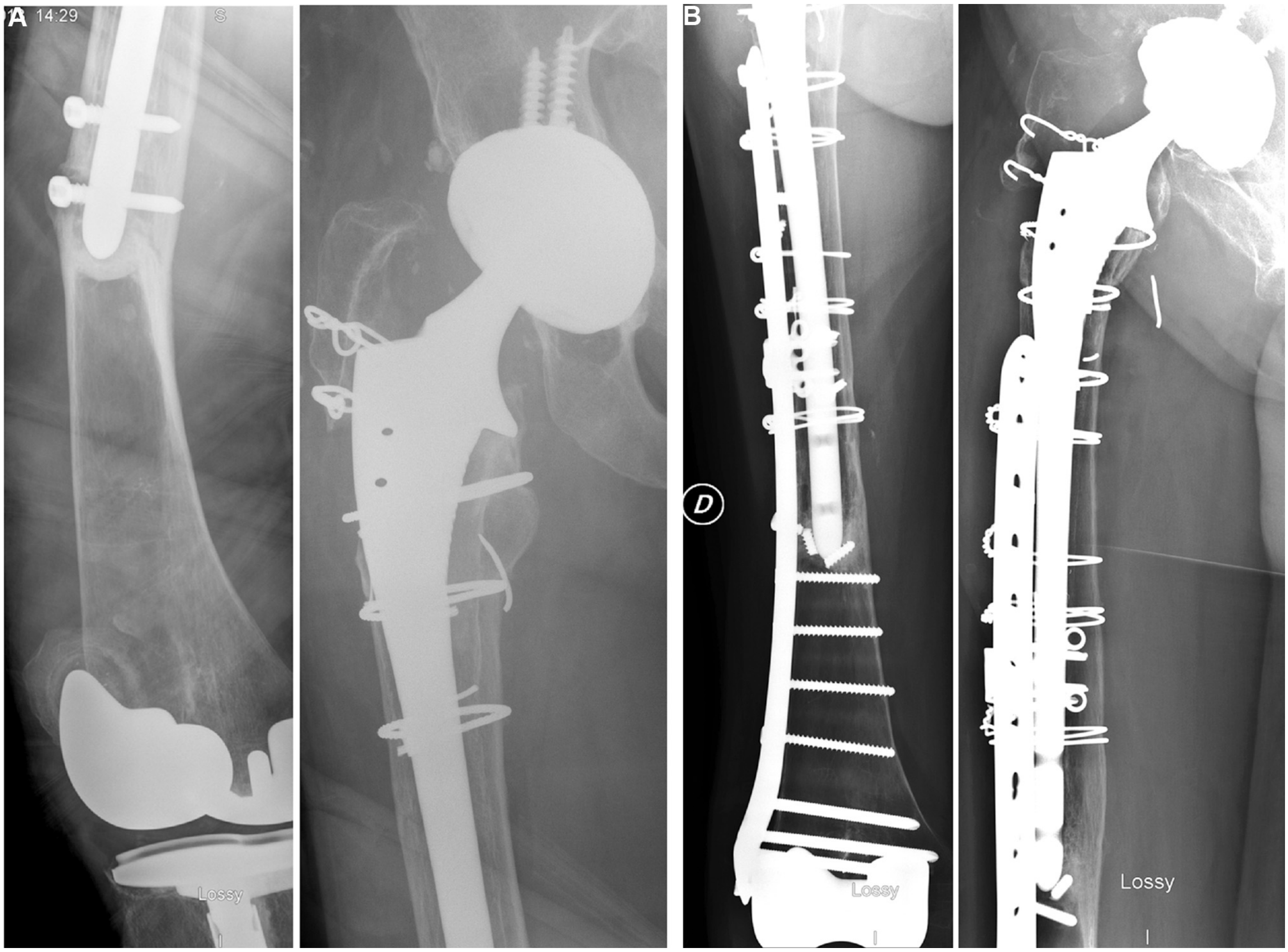

Fig. 1. A. Example of an interprosthetic fracture in the right leg of an 89-year-old female, who is Type B at the knee and Type C (SOFCOT) at the hip. B. X-rays at 2 years' follow-up showing a long locking plate that bridges the femoral stem portion of the total hip arthroplasty.

Table 1
Geriatric trauma clinical scores for the 9 patients who died within 6 months of their surgery.

Time frame	Sex/age (years)	ASA score [20]	Parker and Palmer score [21]	Katz score [22]
1st week	F/91	4	3	4.5
	F/90	4	3	2
	F/85	4	6	6
2nd month	F/90	3	3	6
	F/91	4	2	1.5
	F/80	3	2	3
	F/91	3	3	5
3rd month	F/96	2	5	5
	F/90	2	3	4

F: Female, ASA: American Society of Anesthesiologists.

age, and 7 were at least 90 years of age (Table 1). The mean age of the patients who died was significantly higher than of those who were still alive (89.3 ± 4.4 versus 81.5 ± 9.8; $p = 0.02$) as was their ASA score (3.2 ± 0.8 versus 2.5 ± 0.6; $p = 0.01$) while their Parker scores were lower (3.3 ± 1.3 versus 5.3 ± 2.6; $p = 0.05$). Their Katz scores were not statistically different (4.1 ± 1.6 versus 4.5 ± 1.6; $p = 0,5$).

Early general complications occurred in 13 patients: 4 cases of urinary tract infection, 3 of mental confusion, 3 of anemia, 2 of bed sores, 1 of pyelonephritis and 1 of acute decompensated heart failure. Five patients had an early surgery-related complication: 1 hematoma, 2 surgical site infections resolved with lavage and appropriate antibiotic therapy, 2 fixation failures at 2 and 6 months that were revised with a longer plate.

3.2. *Clinical and radiological outcomes*

The clinical and radiological outcomes after a mean follow-up of 27.6 ± 17.2 months (minimum 12 months' follow-up) are known for 40 patients. The mean final Parker score was 3.37 ± 2.6 and the mean Katz score was 2.98 ± 1.8; both were significantly different from the preoperative scores by 5 ± 2.4 and 4.4 ± 1.4 points, respectively ($p < 0.001$). Twenty-eight patients (55%) were living at home and 21 (45%) in a nursing home. Six patients died after the 6th month: 3 between months 12 and 18, 2 between months 19 and 40 and 1 at 50 months. This corresponds to a 15% late mortality rate. The overall mortality rate at the longest follow-up was 31% (16/51). The mean survival was 3.45 years.

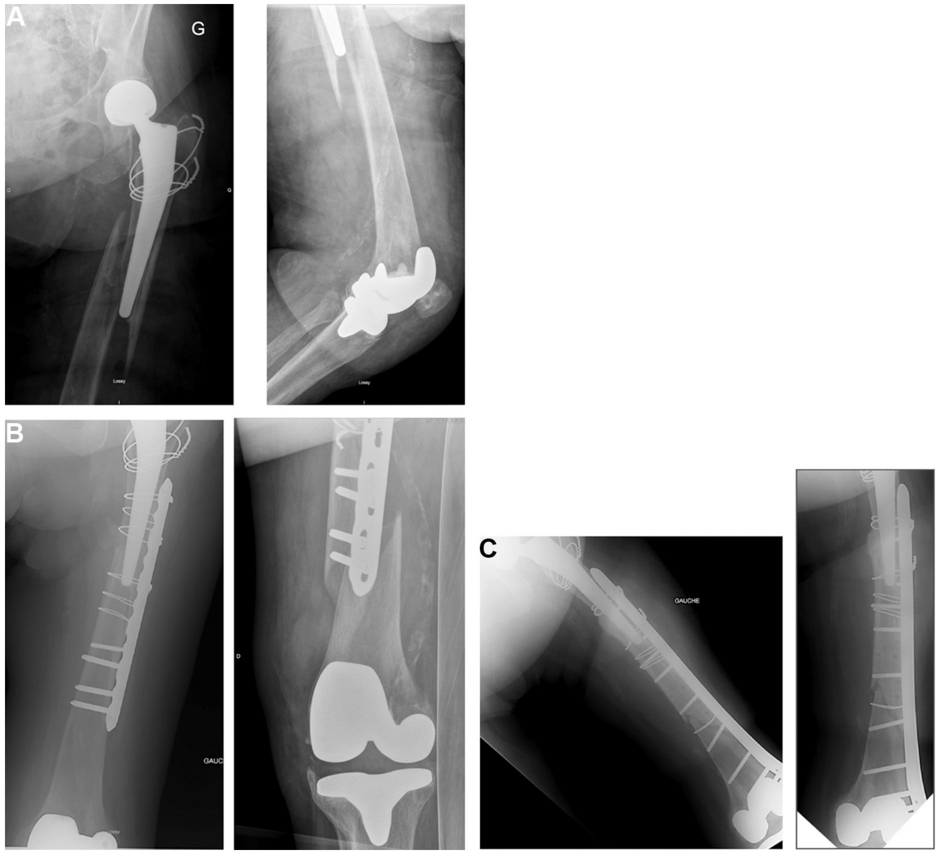

Fig. 2. A. An 82-year-old patient living at home with Parker score of 6. She underwent TKA in 2003 due to knee osteoarthritis and bipolar THA in 2011 due to a femoral neck fracture. She fell at home in 2013 and suffered a type B1 fracture. B. Locking plate fixation of the fracture through a standard approach. She started walking again 3 months postoperative. She fell another time and suffered another fracture. C. Fixation using a plate that rests against the condyles and bridges the proximal fracture that had healed.

The mean time to union was 19.25 ± 8.8 weeks for the 36 fractures that healed. There were 10 late complications: 6 mechanical (4 nonunion, 1 repeat fracture (Fig. 2), 1 fixation failure), 2 surgical site infections and 2 cases of secondary implant loosening. All these complications resolved after a new surgical procedure.

4. Discussion

The main findings of this study are the fragility of the patient population in question and the considerable early morbidity and mortality. Eight out of 10 patients were above 80 years of age and 1 out of 10 was more than 90 years of age. The ASA score was 3 or higher in more than 50% of patients. The patients had minimal autonomy, as the Parker score was 4 or less in more than 50% of patients. The vast majority of fractures had a rotational component (spiral or oblique in 8 of 10 cases) and was located in the middle or distal third but sparred the implants. The mortality rate, surgical site infection rate and early mechanical failure rate (first 6 months) were 20%, 4% and 4%, respectively. After at least 12 months' follow-up, the mortality rate was 31%, the infection-related complication rate was 4% and the late mechanical complication rate was 4%, which equates to 8% and 16% for the entire study. All of these values are much lower than the ones in our study. The functional outcomes indicate a 1.5-point decrease in the Parker score and a 1.4-point decrease in the Katz score ($p < 0{,}001$). The proportion of patients residing in nursing homes went from 22% to 45%.

Six recent published studies on this topic feature a total of 130 patients. Overall, they had a 6.5% mortality rate at the longest follow-up, no surgical site infections and a 10.7% rate of major revision due to the IFF (Table 2) than the ones in our study. The high early mortality rate in our study can be explained by a set of interrelated epidemiological characteristics: relatively higher mean age ($p = 0.02$), higher ASA score, functional dependency and cognitive decline before the IFF. Few studies feature geriatric trauma scores, which make it difficult to compare the clinical outcomes in our study. Three studies reported the patients having no preoperative comorbidities [12,14,15] while other studies listed them but not in detail [10,12,17]. The high rate of mechanical complications can be explained by the surgeons not following the technical rules of fracture fixation, in particular use of plates that are too short and a standard surgical approach (Table 3), despite published recommendations [4,16,23–26].

The main takeaways from this analysis are that patients who suffer an IFF are very fragile and that technical errors are often made during fracture fixation. They propose a treatment algorithm based on the one presented by Ochs et al. [27] that takes into consideration the appearance and level of the peri- or intraprosthetic fracture and the stability of the hip and/or knee implant prior to the fracture or destabilized by the fracture. The most common presentation is an IFF in which both implants are still stable (double type C in Vancouver/SoFCOT on the hip and knee); this can be treated with locking plate fixation. The construct must avoid stress risers between the two implants and must bridge the existing implants [28–31]. Lateral cortical fixation satisfies the prescribed rules for periprosthetic fractures by favoring minimally invasive surgery with a long construct with locking screws placed in at least 4 or 5 holes beyond the fracture site and locking near the site of "complex" fractures but away from more "simple" fracture sites [16,24–26,32]. Proximally, over the stem, plate fixation over several centimeters can only be accomplished with short locking screws or wire cerclage. With a type B1 injury, the plate must be as placed as high as possible on the lateral aspect of the trochanter. Some authors

Table 2
Main published studies of IFF in the international literature. Only studies with more than 10 patients were included.

Authors Time frame	Center	*n* (sex)	Mean age (years)	Type	Follow-up (months)	Fixation/revision	Post-op complications (all types)/local infection	No. of deaths (months)	Union (*n*)	Revision for failure (*n*)
Mamczak et al. [10] 1989–2009	2	20 (14F/6M)	80 (56–98)	9C/14B1	12 (4–119)	20/0	5/0	4 (10–60)	20/20	2
Michla et al. [11] 2000–2014	1	8 (6F/2M)	78 (53–92)	8C	3–13	6/2	0/0	1	8/8	–
Sah et al. [12] 2002–2006	2	22 (18F/4M)	75 (41–92)	6 B1/16C	17.7 (5–47)	22/0	0/0	0	20/20	1
Hou et al. [14] 2004–2010	1	13 (10F/3M)	81 (61–94)	2B1 1B2/9C	28 (12–50)	9/4	0/0	2 (1–4)	13/13	1
Platzer et al. [15] 1992–2008	1	23 (15F/8M)	79.2 (61–92)	15B1/3B2/4C	17.7 (5–47)	19/4	4/0	1 (1)	19/22	4
Ebraheim et al. [17] 2002–2013	1	17 (14F/3M)	80.5 (61–92)	1A/2B1/2/B3/ Su	17.7 (5–47)	16/1	3/0	2 (1–6)	9/12 (2PDV)	3
Hoffmann et al. [18] 2005–2012	1	27 (25F/2M)	80.2 (61–92)	6B1/12C/1D	?	27/0	3/0	0	24/27	3
Total	9	130 (102F/28M)				119/11	15/130 (11.5%)/0	10/130: 7.7%	104/113: 92%	14/130: 10.7%
Current study 2009–2015	6	51 (49F/2M)	82.5 (55–97)	19C/11D /19B1/2B3	27.6 (12–45)	47/2	13/51 (25.5%)/2.4%	16/51: 31.4% (1–50)	32/36: 88.9% (living)	8/50: 16%

F: Female, M: Male. Center: number of teams and hospitals involved. Type: based on Vancouver/SoFCOT [4] classification. Type D corresponding to a type C with less than two diaphysis widths between the extension stems of the hip and knee implants according to Soenen et al. [13]. Fixation/revision: number of patients who underwent fracture fixation only/number of patients who underwent revision of one or both arthroplasties. Post-op complications: mechanical or infection-related complication at the fracture site directly related to the surgical procedure Union: number of patients who achieved primary fracture union. Revision: number of major revision procedures at the surgical site.

Table 3
Demographics, outcomes and reasons for early and late mechanical complications after FFI.

Patient Sex/age	Vancouver/ SOFCOT	Initial treatment	Type of complication	Time to occurrence (months)	Plausible reason
Female 73	D	Standard plate Direct approach	Recurrent fracture	3	Short plate
Female 82	B1 PTH	Standard plate Direct approach	Fixation failure	6	Short plate
Female 70	D	Standard plate Direct approach	Fixation failure	2	
Female 67	D	Locking plate Direct approach	Non-union	24	Short plate
Female 82	C	Locking plate Direct approach	Non-union	12	Short plate
Female 80	C	Locking plate Minimally invasive approach	Non-union	6	Residual valgus and recurvatum
Female 59	C	Locking plate Minimally invasive approach	Non-union	23	Short plate
Female 86	C	Standard plate Direct approach	Non-union	6	Short plate

"Short plate" corresponds to a fixation plate that does not bridge the femoral stem or reach the distal epiphysis. Type D was described by Soenen et al. [13] as a fracture between the extension stems of hip and knee implants.

recommend reversing (right/left) the distal condylar plate to allow the plate with its locking screws holes to be used in the trochanter area. However, not every screw should be used, as this may cause a postage stamp fracture of the trochanter [16]. The drawback of this type of construct is that it must stop at the distal one-quarter of the femur where the plate is straight. This trick can only be used when a TKA with femoral extension stem is present, as this allows the reversed plate to bridge the site without reaching the lateral condyle (Soenen et al. [13] type D fracture). When the fracture site is more distal, the plate must always have multiple epiphyseal contact points in the area of the TKA's femoral condyle component.

If the IFF occurs away from or near a loosened implant (type B2 or B3), the consensus is to change the THA or TKA in combination with fracture fixation [33,34]. The hip revision implant has a long stem that bridges the fracture site with primary stability ensured by press-fit or locking. The associated plate will extend beyond the stem proximally by three or four holes and rests on the condylar area in which the TKA is located. The knee revision implant will be posteriorly stabilized or be hinged with an intramedullary stem. The straight plate will extend beyond both ends of the stem.

IFF in combination with loosening of both the TKA and THA is a very rare condition. It has been suggested that the femur be completely replaced [3,13,27,35] or a metal sleeve interposed between the two implants [36]. These various technical options must be considered in the context of the patient's comorbidities, initial autonomy and cognitive status. Thus a type B2 injury, which was well tolerated before the fall and requires the arthroplasty implants to be changed, can be managed with fixation only. Also, it is preferable to take enough time before the surgery to stabilize any unstable comorbidities, gather all the logistical know-how and set up a team experienced in both trauma and arthroplasty revision.

The limitations of this study are related to its multicenter, multi surgeon and retrospective design. Nevertheless, this is the largest cohort published up to now on this topic (Table 2). While we cannot be sure that every patient with an IFF was included at each facility, the large number of cases included increases the reliability of our analysis. While the long period of patient inclusion can explain the small number of fractures treated with locking plates, especially with a minimally invasive approach, it allowed us to identify factors contributing to failure, especially technical errors. The strengths of this study are the large number of patients included and the use of validated geriatric trauma scores, which could be used in a cross-sectional comparison with other published studies.

5. Conclusion

Our hypothesis was not confirmed: the mortality and morbidity rates are high as is the mechanical complication rate. This can be attributed to the poor general condition and functional ability of the patients included in this study. The fragile nature of the patients who suffer an IFF means that rigorous surgical technique must be used. Technical errors in the construct can explain some of the observed mechanical failures. We expect the number of IFF to increase in the future. A prospective study with the proposed treatment algorithm will help to validate the surgical strategy, while taking into consideration the patients' general condition and function, and the nature of the fracture.

Disclosure of interest

The authors declare that they have no competing interest.

Outside this work, Paul Bonnevialle is a research and education consultant for Stryker, while Matthieu Ehlinger is an educational consultant for DePuy-Synthes, Lépine and Newclip.

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Contribution

P. Bonnevialle performed surgical procedures, collected data, performed the data analysis and wrote the article.

X. Nicolau, M. Arboucalot, M. Lebaron collected data and performed the data analysis.

P.S. Marcheix, C. Chantelot, D. Mainard, M. Ehlinger performed surgical procedures, collected data and performed the data analysis.

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