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Lower reoperation rate with locking plates compared with conventional plates in Vancouver type C periprosthetic femoral fractures: A register study of 639 cases in Sweden

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ABSTRACT

Aim: To investigate demographics and outcomes of Vancouver type C periprosthetic femoral fractures (PPFF) treated with open reduction and internal fixation.
Methods: Patient data were obtained from medical charts of cases reported to the Swedish Hip Arthroplasty Register and/or from the National Patient Register. Vancouver type C fractures undergoing surgery between 2001 and 2011, in patients who had received their primary THR between 1979 and 2011, were included. Any further reoperation performed between 2001 and 2013 and related to the PPFF constituted the primary outcome.
Results: A total of 632 patients with 639 Vancouver type C fractures were identified. The majority of the patients were women (84%) and they had a fracture distal to a cemented stem (95%). The mean age at the time of fracture was 72 years. Treatment was performed with a locking plate (363 cases), a conventional plate (184 cases), an intramedullary nail (62 cases), or with double plating (30 cases). The overall reoperation rate was 17%, and mortality within one year of the operation was 16%. Locking plates had a significantly lower reoperation rate than conventional plates ($p<0.001$) and intramedullary nailing ($p=0.005$). Interprosthetic femoral fractures did not have a statistically different outcome compared with non-IPFFs.
Conclusions: The lowest reoperation rate was observed using locking plates in Vancouver type C fractures when compared with conventional plates or intramedullary nailing. The presence of an ipsilateral knee prosthesis did not influence the outcome of the surgical treatment.

Introduction

A Vancouver type C periprosthetic fracture, is a femoral fracture distal to a hip replacement, and can be treated with conventional methods [1]. Commonly, trauma surgeons treat these fractures, and they are only occasionally reported to arthroplasty registries, because revision surgery is rarely performed. Type C fractures have therefore been studied as distal femoral fractures (DFF) with or without a prosthesis [2,3], or in conjunction with Vancouver type B fractures (PPFF) [4,5], or as interprosthetic fractures between a hip and a knee prosthesis [5]. Large epidemiological studies, based on register data [6,7], have not described the treatment of these fractures in detail, and there is a high probability of underreporting [6]. Due to theoretical advantages [8], the use of locking plates is preferred for the treatment of these fractures [9], but it has still not been proven to be superior to conventional plates, in clinical trials [10]. To our knowledge, it is not known whether the presence of an ipsilateral TKR can influence the outcome of the surgical treatment of a Vancouver type C fracture.

The aim of this observational study was to describe the demographic characteristics of patients with a fracture distal to a primary THR, compare the outcomes after treatment with various methods of open reduction and internal fixation (ORIF), and investigate the influence of an ipsilateral TKR on the outcome. Reoperation was the outcome measurement.

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Patients and methods

Data collection

All primary THRs reported to the Swedish Hip Arthroplasty Register (SHAR) since it began in 1979 and undergoing surgery due to a Vancouver type C fracture between 2001 and 2011, were included in this study. Periprosthetic fractures treated surgically in Sweden between 1979 and 2000 have previously been described [6]. Patients were followed until any reoperation for any reason, death, emigration, or 31 December 2013, corresponding to a minimum follow-up of two years. All primary THRs and all types of reoperation are supposed to be reported to the SHAR. The completeness of reporting of primary THRs and revisions in the SHAR is 98% and 93%, respectively [11]. Previous studies showed a poorer completeness regarding reoperations for any reason [12], and due to infection [13]. Reoperation is defined as any further surgical intervention related to the index hip arthroplasty, irrespective of whether the prosthesis or parts of it have been exchanged, extracted, or left untouched. Fractures distal to a hip prosthesis (Vancouver type C) are therefore supposed to be reported to the SHAR, even if the surgical treatment may not affect the hip prosthesis. In order to ensure that all surgically treated type C fractures, and any other type of further reoperation following these fractures, were included in this study, cross-matching between the SHAR and the National Patient Register (NPR) was performed in two stages. All public and private health care providers are obliged to report in-patient and out-patient care to the NPR. At the first cross-matching [14], we searched for surgically treated PPFFs between 2001 and 2011, that were only registered in the NPR. The completeness in the SHAR was found to be 55%, as regards reporting any type of reoperation due to PPFF, and 97% regarding the registration of stem revisions (the exchange or extraction of any part of the stem) due to PPFF. After the addition of these primarily unreported cases to the SHAR database, a second cross-matching was performed in order to detect any kind of reoperation between 2001 and 2013, following the treatment of a PPFF and only registered in the NPR. The linkage was based on KVÅ treatment codes (Klassifikation av vårdåtgärder, Classification of Healthcare Procedures), corresponding to the OPCS (Classification of Intervention and Procedures) of the NHS (National Health Service). Data on any kind of surgical treatment on fractures of the femur (NFJ) or knee (NFG), hip revision (NFC), amputation (NFQ), excision arthroplasty (NFG), extraction of instrument (NFU), bone transplantation (NFN), arthroscopy/endoscopy or reduction of a dislocated hip replacement (NFH), reoperation due to infection (NFJ), and any other reoperation on the femur (NFW), were derived from the NPR database. All medical records of cases only reported to the NPR were collected, while medical records of reoperations already registered in the SHAR had been prospectively reviewed by the personnel at the SHAR when the data were entered. Information regarding the classification of a PPFF, the surgical procedure, the mechanism of injury, the length of stay (LOS) in hospital postoperatively, weight-bearing after surgery, and the place to which patients were discharged was extracted from the medical charts. The classification process of the PPFFs, according to the Vancouver classification system, and its validation have been described in detail, in a previous publication [14]. Information on the reason for reoperation and the type of operation performed was obtained from the SHAR or the medical records of cases identified after the second linkage with the NPR (cases missing in the SHAR). Interprosthetic femoral fractures (IPFF) were tracked by either information from the medical records or from a data linking with the Swedish Knee Arthroplasty Register (SKAR).

Table 1
Other exclusion criteria, $n = 93$.

Intra-operative fracture	57
Active deep infection at the time of PPFF	20
Perforation only	10
Iatrogenic fracture during TKR surgery	5
PPFF due to sawing (non-iatrogenic)	1

Table 2
Excluded Vancouver type C fractures treated with various methods, $n = 28$.

Surgical treatment	Cases (n)
Screw fixation only	10
Stem revision	5
Transfemoral amputation	5
Fixation with both plate and intramedullary nail	2
Primary TKR	2
Secondary TKR	1
Unknown type of plate	1
External fixation	1
Fixation with strut, cerclage, and screw	1

Exclusions and definitions

Only conventional primary THRs reoperated for the first time due to a post-operative PPFF were included. Cases with an unknown type of hip prosthesis, date of intervention, diagnosis at primary THR, or lack of information regarding the type of periprosthetic fracture and its treatment were excluded. Further exclusion criteria were a diagnosis of malignancy (at primary THR or at PPFF), infection, previous history of hemi-arthroplasty, iatrogenic fractures, and perforations without a complete femoral fracture (Fig. 1, Table 1). The focus of the current study was Vancouver type C fractures treated with a conventional plate (CP), a locking plate (LP), an intramedullary nail (IMN), or with double plating (DP), irrespective of the type of plate used. Fractures treated with a revision of the femoral stem or methods other than those mentioned above were excluded (Table 2). In the first part of this study, the demographics and the outcome for all four surgical methods (CP, LP, DP, IMN) were reported. Secondly, we compared the group of type C fractures treated with a CP or an LP. In this sub-analysis, inter-prosthetic fractures were further excluded. Cable plates (e.g. Dall-Miles, Cable-Ready), condyle plates (e.g. Richard, DCS), and plates only fixed with non-locking screws and/or cerclage wiring were referred to as conventional plates. If only cerclage and/or non-locking screws were used for the fixation of a locking plate (e.g. LISS, LCP, Peri-Loc), the case was registered in the CP group. Weight-bearing postoperatively was divided into protected and not allowed. The former includes both toe-touch, and partial and full weight-bearing, because it may be difficult for elderly patients to follow instructions regarding this parameter [15]. The postoperative length of stay was only calculated in patients discharged to their homes, due to different process protocols within hospitals regarding the place of stay postoperatively (rehab department, intermediate care units).

Outcome measurement and statistics

The primary outcome measurement was any kind of reoperation after a previous operation due to PPFF distal to a primary hip stem (Vancouver type C). Reasons for reoperation could be

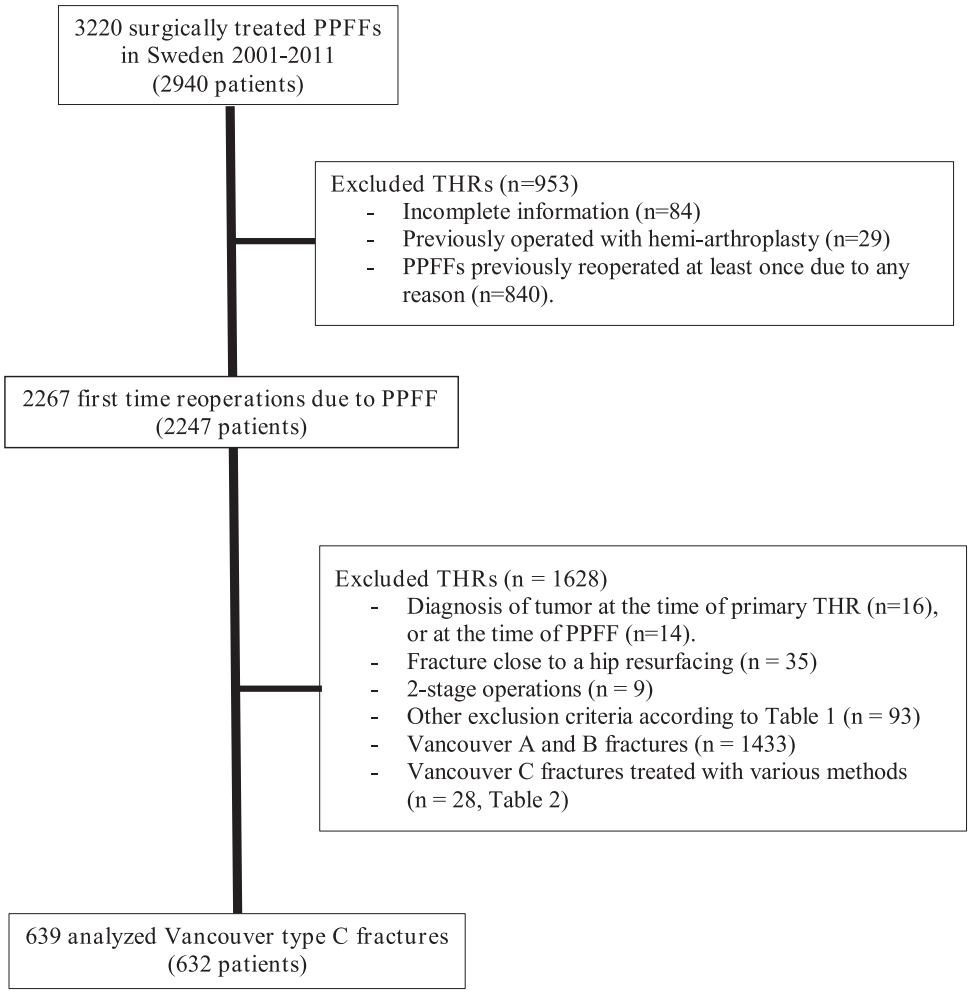

Fig. 1. Flow chart. Exclusion criteria.

infection, hip dislocation, stem loosening (with or without loosening of the cup), pain, technical reasons, or "nonunion". These reasons were regarded as "PPFF-related". The "nonunion" group included reoperations due to pseudoarthrosis, failure of fixation, or re-fracture. Transfemoral amputations with a diagnosis of arterial insufficiency, and reoperations due to cup loosening were not regarded as being related to the previously treated PPFF and were therefore censored in the Cox regression analysis. In the figures, tables, the following text, and statistical calculations, the word "reoperation" refers to PPFF-related reoperations, while "any kind of reoperation" refers to all types of reoperations, regardless of their cause. The outcome measurement in the sub-analysis of CPs versus LPs was reoperation within two years of PPFF treatment.

Calculations of mortality rates and time to death after PPFF were based on the total number of patients and not cases, after excluding any second operation performed contralaterally. A comparison of means was performed using the *t*-test and, when applicable, one-way ANOVA and the Tukey test. The Mann-Whitney test was used to compare median values between groups. Reoperation rates and comparisons of categorical variables were performed with the χ^2-test (Fisher's exact test). We used Cox regression to calculate the risk of reoperation, and the Kaplan-Meier analysis (log rank test) for the two-years survival. P-values were two-sided with a significance level of <0.05, and 95% confidence intervals (CI) were calculated. Statistical calculations were made using IBM SPSS statistics version 25 (IBM Corp, Armonk, NY, USA). The STROBE (strengthening the reporting of observational studies in epidemiology) checklist was used.

Results

The study material

Between 2001 and 2011, 3.220 reoperations (2.940 patients) due to periprosthetic femoral fracture were registered. After the exclusions listed in Fig. 1, and Tables 1 and 2, 639 Vancouver type C fractures were left for analysis (632 patients). In five of seven patients with bilateral PPFF, the fractures (left and right side) occurred simultaneously. The mean time between primary THR and PPFF was 7.1 years (CI:6.7–7.5). Only 121 type C fractures (19%) were primarily (before the first cross-matching) registered in the SHAR. Until the end of 2013, 108 cases (105 patients) of the total of 639 first-time-treated type C fractures (16.9%) underwent any kind of reoperation and 97 of these reoperations (96 patients) were PPFF-related (15.2%). The second cross-matching revealed a much higher registration rate, with 79 reoperations out of 108 (73.1%) being primarily reported to the SHAR. The majority of reoperations (93/108) took place within two years of the treatment of a Vancouver C fracture. The mean follow-up time between PPFF and reoperation was 3.3 years (CI:3.1–3.5).

Demographics of all treatment groups

The demographics of Vancouver type C fractures, treated with four different methods, are shown in Table 3. Only 30 femurs (4.7%) had an uncemented primary THR. The majority of patients were women (84.2%), with a lower percentage of women in the DP

Table 3
Demographics and outcome of Vancouver type C fractures treated with plate fixation or intramedullary nailing.

	Type of ORIF IMN, n (%)	One CP, n (%)	One LP, n (%)	DP, n (%)
All fractures	**62**	**184**	**363**	**30**
Interprosthetic fracture	31 (50.0)	32 (17.4)	104 (28.7)	5 (16.7)
Sex, Women	50 (80.6)	157 (85.3)	312 (86.0)	19 (63.3)
Diagnosis, primary OA	31 (50.0)	87 (47.3)	212 (58.4)	20 (66.7)
Mean age in years (CI)				
at primary	68.6 (65.7–71.4)	72.1 (70.2–74.0)	72.4 (71.2–73.5)	73.1 (69.4–76.8)
at PPFF	75.1 (72.3–77.9)	78.4 (76.7–80.2)	79.9 (78.8–81.1)	80.8 (77.9–83.7)
Weight bearing				
Not allowed	36 (58.1)	106 (57.6)	178 (49.0)	7 (23.3)
Protected	24 (38.7)	77 (41.9)	184 (50.7)	22 (73.3)
Unknown	2 (3.2)	1 (0.5)	1 (0.3)	1 (3.3)
Discharged to				
Other unit	44 (71.0)	138 (75.0)	255 (70.2)	17 (56.7)
Home	12 (19.3)	28 (15.2)	78 (21.5)	7 (23.3)
Died	1 (1.6)	4 (2.2)	3 (0.8)	2 (6.7)
Unknown	5 (8.1)	14 (7.6)	27 (7.5)	4 (13.3)
Postoperative LOS in days, median (interquartile range)*	9.5 (5)	9.5 (9)	9.0 (5)	12.0 (6)
Reoperation until 2013				
Related to PPFF	15 (24.2)	43 (23.4)	37 (10.2)	2 (6.7)
All causes	15 (24.2)	48 (26.1)	43 (11.8)	2 (6.7)
Mean time of follow-up, years (CI)	4.6 (3.7–5.6)	3.7 (3.2–4.2)	2.8 (2.6–3.0)	3.7 (2.6–4.9)
Deceased (31.12.2013)	38 (61.3)	137 (74.5)	180 (49.6)	22 (73.3)

IMN (Intramedullary Nail), **CP** (Conventional Plate), **LP** (Locking Plate), **DP** (Double Plating), **OA** (osteoarthritis), **PPFF** (periprosthetic femoral fracture), **LOS** (length of stay).
Percentages are related to number of cases treated with each specific method.
* The postoperative length of stay (LOS) refers only to patients discharged to their home.

group compared with the CP ($p = 0.008$) and LP ($p = 0.003$) groups. The mean age at the time of primary THR was 71.9 years (CI: 71.1–72.9) and, at the time of PPFF, 79.1 years (CI: 78.2–80). A statistically significant difference between the groups, regarding the age, was only noted for patients undergoing surgery with an IMN, who were younger at the time of fracture compared with individuals treated with LP ($p = 0.008$). Primary OA was the most common diagnosis, with a statistically significant higher percentage in the LP than in the CP group ($p = 0.014$). The highest proportion of IPFFs was noted in the IMN group, which was statistically different from all other groups. A significant difference was also noted between the CP and LP groups ($p = 0.005$). The number of cases per year, divided into treatment groups, is shown in Fig. 3. Of all CPs, 83.6% were inserted between 2001and 2006, whereas 84.2% of all LPs were inserted between 2007 and 2011. This observation is mirrored by a shorter mean follow-up time ($p = 0.003$) and it most probably explains the lower percentage of deaths ($p < 0.001$) in the LP group compared with the CP group. A significantly longer follow-up was also noted in the IMN group when compared with fractures treated with an LP ($p < 0.001$).

Postoperative course and outcome for all treatment groups

The mean time between PPFF and any second reoperation was one year (CI:0.8–1.3). This did not differ statistically between the four treatment groups. The majority of patients were recommended to undertake no weight-bearing postoperatively, except for the DP group, in which protected weight-bearing was allowed in 73% of the cases. Only one in five patients (19.6%) was discharged to home. No information regarding the place of residence before admission was available. The median LOS, for those discharged to home, was 9 days (interquartile range IQR: 6 days), and it did not differ statistically ($p = 0.06$), when comparing the length of stay in 2001–2006 (10 days, IQR: 8) with the following period in 2007–2011 (9 days, IQR: 5). A statistically significant difference was only noted between the LP and the DP groups ($p = 0.04$, Table 3), for the whole study period.

Four fractures treated with CP and six treated with LP underwent a reoperation due to cup loosening. One fracture, fixed with a CP, underwent a reoperation involving transfemoral amputation due to arterial insufficiency. All the other reasons for reoperation (PPFF-related reoperations) and the reoperation rates are shown in Fig. 2. The lowest reoperation rate was noted in the DP group (Table 3), but this was only statistically significant when compared with the IMN group ($p = 0.048$) and close to significance when compared with the CP group ($p = 0.05$). The combinations of plate fixation used in the DP group were: two CPs (19 cases, one reoperation), two LPs (seven cases, no reoperation), CP-LP (three cases, one reoperation), and one CP combined with one plate of unknown category (one case, no reoperations). Fractures treated with an LP had a significantly lower reoperation rate compared with those treated with an IMN ($p = 0.005$), and CP ($p < 0.001$). The presence of an ipsilateral TKR did not influence the reoperation rate, either in the entire fracture population, or in the treatment groups separately. The incidence of reoperations following a PPFF, is shown in Fig. 4.

Comparison between locking and conventional plates (sub-analysis)

In the separate analysis, between conventional and locking plates (Table 4), where interprosthetic fractures were excluded, no significant differences in the demographics of these two treatment groups were noted. CPs had a higher reoperation rate (Table 4), and poorer survival within two years of the PPFF, in comparison with LPs (Fig. 5). The crude hazard ratio for reoperation increased when conventional plates where used (HR: 2.4, 95% CI: 1.4–4.4, $p = 0.002$). No adjustment for covariates was made due to the relatively small number of cases (47 reoperations within two years).

Mortality after Vancouver type C fractures

Ten patients (1.6%) died during their hospital stay. One-year and two-year mortality was 15.7% (99/632 patients) and 24.2% (153/632 patients), respectively, while 373 patients (59%) had died at the end of 2013. Mortality within two years of PPFF was

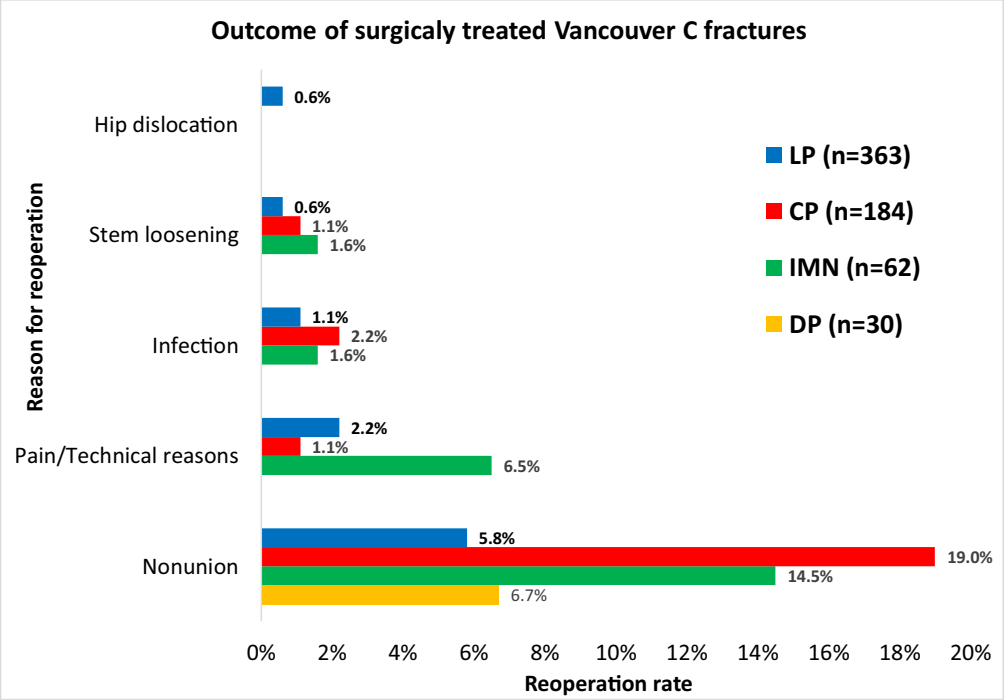

Fig. 2. Reoperation rates in relation to treatment method at the time of PPFF, and reason for reoperation. **LP** (Locking Plate), **CP** (Conventional Plate), **IMN** (Intramedullary Nail), **DP** (Double Plating).

significantly higher ($p<0.001$) in individuals older than 80 years (35.2%, 113/321), compared with those aged 80 and under (12.9%, 40/311). As expected, the mean time between an operation due to PPFF and death, was shorter ($p<0.001$) for patients older than 80 years (2.7 years, CI: 2.4–3.0), than for the younger group (3.9 years, CI: 3.4–4.3).

Discussion

We found a significantly lower reoperation rate when locking plates were used compared with conventional plates for the treatment of femoral fractures distal to a primary THR. Fixation with a conventional plate involved a two-fold higher risk of reoperation within two years after the treatment of Vancouver type C fractures. Theoretically, locking plates offer many advantages in the fixation of distal femur fractures, compared with conventional plates [8]. To our knowledge, this is the largest published material regarding this type of periprosthetic fracture. Molina et al. reported 165 Vancouver type C fractures treated with ORIF, from a total of 580 PPFFs [16]. A register study from Sweden described the surgical treatment of 100 type C fractures (62 fractures distal to a primary THR and 38 distal to a revised stem) [6]. The authors did not investigate different types of osteosynthesis but compared the outcome after using osteosynthesis, or stem revision in general.

A systematic review of mixed material (hemi-arthroplasties, primary and secondary THRs) revealed a higher nonunion rate for conventional plates but similar reoperation rates, when compared with locking plates [4]. However, this review included all types of PPFF, and information about the Vancouver classification or the type of plate was missing in a relatively large number of cases. Vancouver type B1 and C fractures, only treated with ORIF, were studied separately in another systematic review, which excluded interprosthetic fractures [10]. The authors reported similar union rates for Vancouver C fractures treated with locking (93.3%) and non-locking plates (92.9%). The material was based on 71 C fractures, extracted from 13 previously published studies, none of which was a comparative study.

It has been suggested that intramedullary nailing should be avoided when treating fractures distal to a hip prosthesis [17]. The gap left between the proximal tip of the nail and the distal tip of the stem, creates a zone of rising stress [18,19]. This increases the risk of fracture in this region, especially if the bone quality is limited or if the hip stem is loose [20,21]. Fixation with a retrograde IMN has been mostly studied in periprosthetic fractures close to a TKR [22,23]. Nauth et al. suggested the use of IMN when the fracture was significantly proximal to the anterior flange of the femoral component [24]. They also discussed the fact that an IMN requires the presence of adequate bone stock. In our material, patients who received an IMN were younger, which presumably also means that they had better bone quality. We did, however, find a higher reoperation rate when using an IMN compared with locking plates, but we were unable to account for any selection bias. To our knowledge, there is no other comparative study investigating these two fixation methods, in the treatment of Vancouver C fractures.

Fixation with two plates, one longer laterally and one shorter anteriorly (orthogonal plating), has also been suggested in the literature for the treatment of periprosthetic fractures, mainly for Vancouver type B. Biomechanical studies have revealed greater stiffness and a higher number of cycles to failure in favour of orthogonal plating compared with one lateral plate [25,26]. A study of 22 PPFFs (13 type B1 and 9 type C) treated with DP, reported excellent results for B1 fractures and a 33% reoperation rate for C fractures [27]. Good results with double plating were also reported for the treatment of nonunions after PPFFs previously undergoing surgery with ORIF [28]. Our study includes 30 Vancouver type C fractures treated with double-plating and only two reoperations due to fixation failure. A higher percentage of men was noted in this group and relatively more patients were allowed protected weight-bearing, compared with the other treatment methods. It is, however, difficult to generalise and draw secure conclusions about the superiority of this procedure due to the small number of cases.

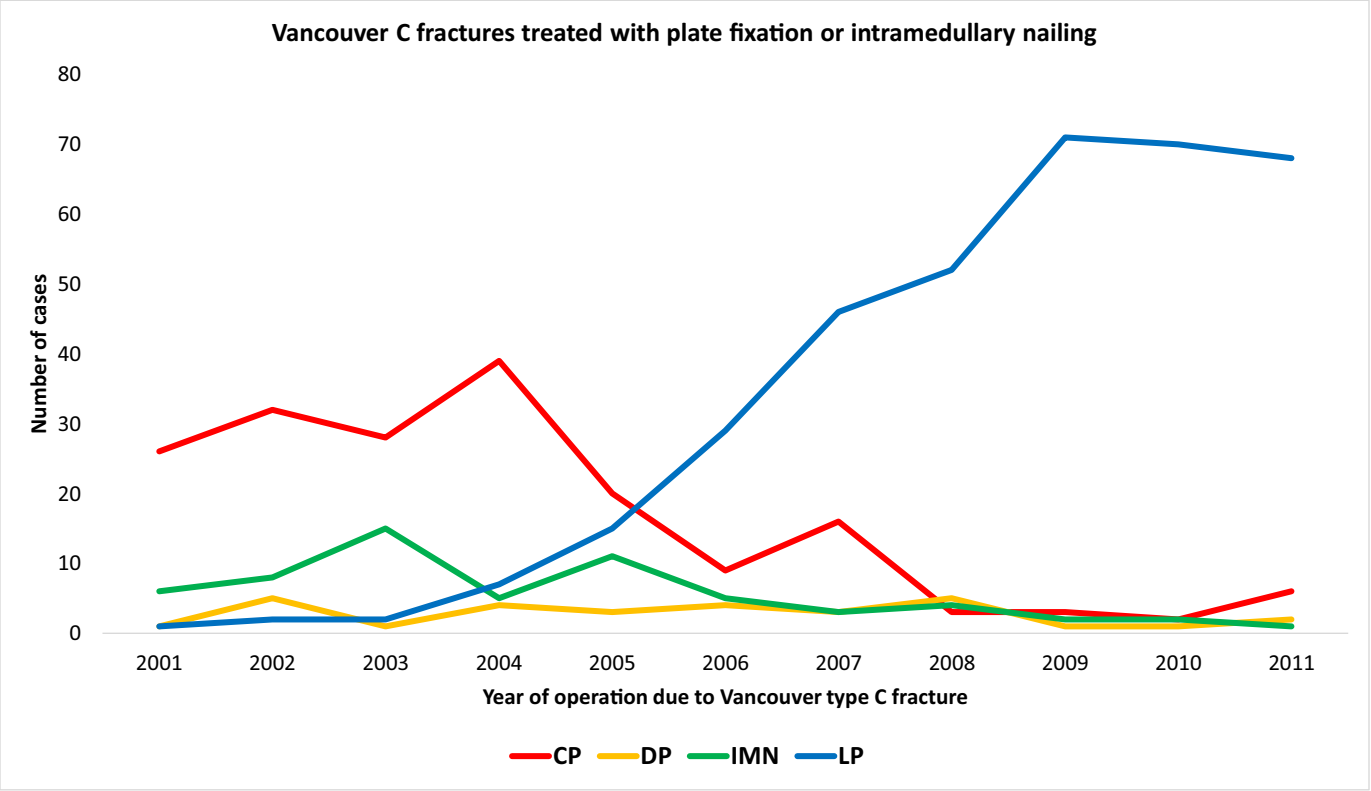

Fig. 3. The use of conventional plates (CP), locking plates (LP), intramedullary nails (IMN), and combination of two plates (DP) for the treatment of Vancouver type C fractures.

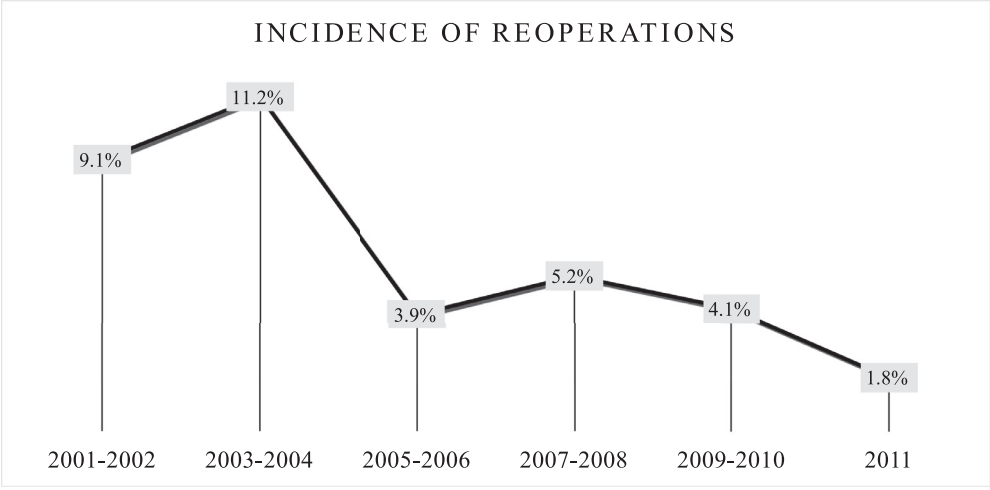

Fig. 4. Incidence of reoperations, after surgical treatment of Vancouver type C fractures. Notice that years 2012 and 2013 are not included due to unknown number of first time PPFFs treated during these years.

Our hypothesis, that inter-prosthetic fractures would have a poorer outcome than those only distal to a THR, was not confirmed by this study. Hoffmann et al. reported three nonunions in 51 PPFFs treated with NCB plates (33 type B1, and 18 type C) [5]. All nonunions were cases with interprosthetic fractures. In contrast to that study, the presence of a TKR did not affect the outcome for the surgical treatment of fractures around 121 hip prostheses (100 primaries and 21 secondary THRs), according to Füchtmeier et al. [29]. Another review study reported similar complication rates for non-IPFFs (17.5%) and IPFFs (13.8%) [4]. The high age and increased mortality rates in this population with interprosthetic Vancouver type C mean that their time of exposure to fracture-related complications will be limited and could possibly explain this finding.

The incidence of reoperations declined after 2004, which may be partially the result of the transition from conventional to locking plates, as shown in Figs. 3 and 4. We report an overall 17% reoperation rate due to any reason and 15% due to PPFF-related complications. These figures cannot be directly compared with previous studies, because most of them investigated both B and C fracture types [4,5], or referred to fractures distal to various types of hip prosthesis (primary or secondary THR and hemiarthroplasty) [6,16,29,30]. Previously reported reoperation-rates ranged

Table 4
Demographics and outcome within two years, after treatment of Vancouver type C fractures with either a conventional plate (CP), or a locking plate (LP). Interprosthetic fractures are excluded.

	CP, n (%)	LP, n (%)	p-value
All fractures	**152**	**259**	
Sex, Women	127 (83.6)	221 (85.3)	0.7
Diagnosis, Primary OA	76 (50.0)	151 (58.3)	0.1
Mean age in years (CI)			
at primary THR	73.4 (71.5–75.3)	72.5 (71.1–73.8)	0.4
at PPFF	79.3 (77.5–81.1)	80.0 (78.7–81.4)	0.5
Weight-bearing			0.3
Not allowed	84 (55.6)	128 (49.6)	
Protected	67 (44.4)	130 (50.4)	
Unknown	1 (0.7)	1 (0.4)	
Discharged to			0.4
Other unit	116 (76.3)	182 (70.3)	
Home	23 (15.2)	57 (22.0)	
Died	4 (2.6)	3 (1.1)	
Unknown	9 (5.9)	17 (6.6)	
Postoperativ LOS in days, median (interquartile range)*	9 (9)	9 (5)	0.3
Mean time to reop., yrs (CI)	0.5 (0.3–0.7)	0.5 (0.3–0.8)	1.0
Deceased within 2 years	36 (23.7)	75 (29.0)	0.3
Reoperation within 2 years	27 (17.8)	20 (7.7)	0.003

Percentages are related to number of cases treated with each specific method.
* The postoperative length of stay (LOS) refers only to patients discharged to their home.

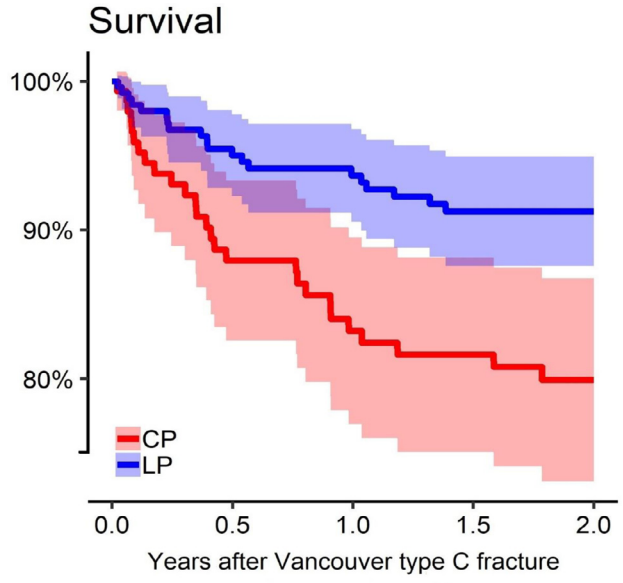

Fig. 5. Cumulative survival (unadjusted), based on PPFF-related reoperation as outcome, after surgical treatment of Vancouver type C fracture, with either a conventional plate (CP) or a locking plate (LP). Mean survival at 2 years was 79.9% (SE 3.5%) for conventional plating and 91.3% (SE 1.9%) for locked plating (log rank test $p = 0.002$). Numbers at risk at the end of 2 years' follow-up were 91 in the CP, and 163 in the LP group.

between 10% and 25%, including studies with both PPFFs and non-periprosthetic femoral fractures [2,31].

More than one-third of the study population (36.8%, 235/639) had either undergone a reoperation or had died two years after the surgical treatment of Vancouver C fractures. This finding underlines the severity of this complication and the fragility of the population at risk. A large register study reported poorer survival (in terms of mortality) for patients with periprosthetic fractures than those undergoing reoperations due to aseptic loosening, infection, and dislocation [32]. We report 16% one-year mortality after a Vancouver C fracture, which is similar to that reported in previous studies [29,33]. In general, one-year mortality after any type of PPFF has been reported to vary between 9% and 18% [6,29,33–36], without any certain influence of fracture type on the mortality rate [33,34]. Bhattacharyya et al. reported that periprosthetic fractures had a similar mortality rate to hip fractures, despite a significantly lower comorbidity index for the PPFF group [34]. As expected, and in accordance with previous studies, we also found a higher mortality rate in elderly patients (>80 years) [37,38].

There are limitations to our study. The classification of the fractures was based on information extracted from the medical charts. Pre- and post-operative radiographs were only requested in cases where information was unclear or classification uncertain. The optimum approach to assess the type of fracture would be to combine information from both radiographs and medical records. We therefore validated the classification process [14] and observed substantial agreement similar to previous validations of the Vancouver classification [39,40]. Moreover, the distinction of a fracture between B and C is considered more secure than between the type B sub-categories. Lindahl et al. reported greater disagreement regarding the classification of type B fractures [30], and Brady et al. reported lower κ-values for this subcategory, than for all fracture types taken together [39].

Another limitation was the use of reoperation as the only outcome measurement. Some patients may not be suitable for further surgery due to severe comorbidities, a few may decline another reoperation, and some of those not undergoing a reoperation may be discontented with their clinical outcome. An unsuccessful outcome may thus be present, despite the absence of a reoperation. Moreover, lower reoperation rates do not necessarily indicate better union rates or a shorter time to union [4]. However, in most instances, a second reoperation in this fragile patient category could be regarded as a poorer outcome than a mal- or a nonunion that does not require additional surgery. A study from the Canadian Orthopaedic Trauma Society reported significantly more reoperations with the LISS plate, than with the DCS, despite no difference in the number of orthopaedic complications [41]. In a review of 11 type C fractures treated with CP, Zuurmond et al. reported that those patients suffering from a femur-related complication had a significantly lower hip score [42]. The above studies support the hypothesis that reoperation as a primary outcome measurement is relevant, although a complete clinical and radiographic examination including PROMs would be preferable.

In the SHAR, where all types of reoperations are supposed to be reported, only one fifth of all C fractures were primarily registered,

before the first linkage. This indicates that our knowledge regarding this devastating complication is restricted to results from retrospective studies of relatively small patient groups often treated at single centres. The strength of the current study is the completeness of the material, based on two consecutive cross-matchings of nationwide databases. This results in high external validity for the Swedish population with periprosthetic fractures and a high probability of very good data quality. Despite the fact that conventional and locking plates were used during different periods of time, the feasibility of comparing these fixation methods during the same follow-up period (two years) and in patient groups with similar demographic characteristics enables more secure conclusions, not least because 86% of the reoperations occurred during the postoperative two years.

Conclusions

In this register-based study, we observed a lower reoperation rate in Vancouver type C periprosthetic femoral fractures treated with locking plates rather than conventional plates.

Ethics

The study was approved by the Central Ethical Review Board in Gothenburg (entry number: 198–12, Date: 2012–04–05).

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Declaration of Competing Interest

All of the above-mentioned authors declare no conflicts of interest for the work reported in this article. 27July19

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