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Surgery Within 24 Hours Reduces Mortality and General Complication Rates in Patients Who Have Periprosthetic Femoral Fractures at the Hip

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ABSTRACT

Background: In patients who have hip fractures, treatment within 24 hours reduces mortality and complication rates. A similar relationship can be assumed for patients who have hip periprosthetic femoral fractures (PPFs) owing to the similar baseline characteristics of the patient populations. This monocentric retrospective study aimed to compare the complication and mortality rates in patients who had hip PPF treated within and after 24 hours.

Methods: In total, 350 consecutive patients who had hip PPF in a maximum-care arthroplasty and trauma center between 2006 and 2020 were retrospectively evaluated. The cases were divided into 2 groups using a time to surgery (TTS) of 24 hours as the cutoff value. The primary outcome variables were operative and general complications as well as mortalities within 1 year.

Results: Overall, the mean TTS was 1.4 days, and the 1-year mortality was 14.6%. The TTS $\leq$ 24 hours (n = 166) and TTS > 24 hours (n = 184) groups were comparable in terms of baseline characteristics and comorbidities. Surgical complications were equally frequent in the 2 groups (16.3 versus 15.2%, $P = .883$). General complications occurred significantly more often in the late patient care group (11.4 versus 28.3%, $P < .001$). In addition, the 30-day mortality (0.6 versus 5.5%, $P = .012$), and 1-year mortality (8.3 versus 20.5%, $P = .003$) rates significantly increased in patients who had TTS > 24 hours. Cox regression analysis yielded a hazard ratio of 4.385 ($P < .001$) for the TTS > 24 hours group.

Conclusions: Prompt treatment is required for patients who have hip PPF to reduce mortality and overall complications.

Considering the increasing number of implanted total hip arthroplasties, epidemiological changes, and increasing comorbidities, the incidence of hip periprosthetic femoral fractures (PPF) is gradually rising [1,2]. Patients who have hip PPF have similar baseline characteristics, such as age, morbidity, and general condition, as patients who have hip fractures (HFs) [2,3]. A short time to surgery (TTS) improves outcomes in these patients [4,5]. Based on distinct data, time guidelines for HF treatment have been included in national guidelines. The time limits for HF treatment in the United States, United Kingdom, and Germany are 24 to 48 [6], 36 [7], and 24 hours [8], respectively. In general, surgical treatment should be recommended as soon as possible.

In the treatment of hip PPF, more complex surgical care and any necessary transfers due to treatment in specialized centers must be considered. Current results in the literature regarding the effects of TTS on hip PPF are contradictory. In studies in which no effect of TTS was demonstrated, the mean TTS was generally very long (> 3 days) [9–11]. In contrast, an effect on outcomes is usually demonstrated in collectives with shorter TTS [12,13]. The sample sizes in these studies were typically small. Moreover, methodological shortcomings further limit the evidence provided in these studies.

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The present study is a monocentric survey of hip PPF using, to our knowledge, the largest sample size to date. The present study aimed to compare the complication and mortality rates in patients who have hip PPF treated within and after 24 hours, and they were followed up for 1 year. It was hypothesized that a TTS > 24 hours increases complication and mortality rates.

Materials and Methods

Study Design

All hip PPF procedures performed in a maximum care arthroplasty and trauma center were reviewed in SAP Enterprise Resource Planning (SAP SE, Walldorf, Germany) from January 1, 2006 to December 31, 2020. All records of inpatient stays, outpatient follow-ups, and available preoperative and postoperative radiographs were evaluated.

In total, 431 patients who had a hip PPF were identified. Patients who had the diagnoses and therapies shown in Figure 1 and a TTS > 4 days were excluded. Decisive influential factors regarding TTS, treatment of concomitant diseases, and organizational reasons were not considered relevant after this time. Longer delays were caused by delayed transfers. The remaining 350 patients who had a hip PPF were divided into 2 groups for further analysis, using a TTS of 24 hours as the cutoff.

The baseline characteristics (Table 1) and surgery-specific variables (Table 2) were collected to compare the 2 groups. The TTS was recorded in minutes from the time of admission to the incision during surgery. The archived reports of external clinics were reviewed to adequately capture the prolonged TTS of the transferred patients. The time of the first radiograph was established as the start of the TTS.

The primary outcome variables were operative and general complications, and 30-day and 1-year mortality. Operative complications included all revisions related to the initial surgery. Implant fractures, failure of osteosynthesis, pseudarthrosis, prosthesis sintering or loosening, dislocation, fracture, infection, hematoma, wound healing disorders, and nerve damage were differentiated. Postoperative infections were defined according to the criteria for periprosthetic [19] or peri-implant [20] infections. Revisions that did not meet these criteria were designated as hematomas or wound healing disorders. General complications included cardiac decompensation, nosocomial pneumonia, apoplexy, thromboembolic events, urinary tract infection, renal failure, delirium, and exitus lethalis during the inpatient stay. The secondary outcome variables were intraoperative blood loss, transfused red blood cell concentrates, hemoglobin (Hb) level on the second postoperative day, and length of inpatient stay (Table 3).

The follow-up duration was 1 year. There were 5 patients (1.4%) who were lost to follow-up after 30 days and 23 patients (6.6%) after 1 year, with an equal distribution between the comparison groups.

Surgical treatment was performed according to the current recommendations for hip PPF [21–23]. Angular stable implants (Less Invasive Stabilization System [LISS] and Locking Compression Plate [LCP], DePuy Synthes, Oberdorf, Switzerland; Non-Contact Bridging [NCB], Zimmer Biomet, Winterthur, Switzerland) were used for plating, combined with cerclages and attachment plates, where appropriate. The Trofix Trochanteric Fixation Plate (Zimmer Biomet) was used for osteosynthesis of the greater trochanter. For revision arthroplasty, a monobloc long stem was used (Wagner SL Revision, Zimmer Biomet). In selected cases, a CLS Spotorno stem (Zimmer Biomet) was implanted if the bone quality was very good. Proximal femur replacement was performed using the Megasystem-C (Waldemar Link, Hamburg, Germany).

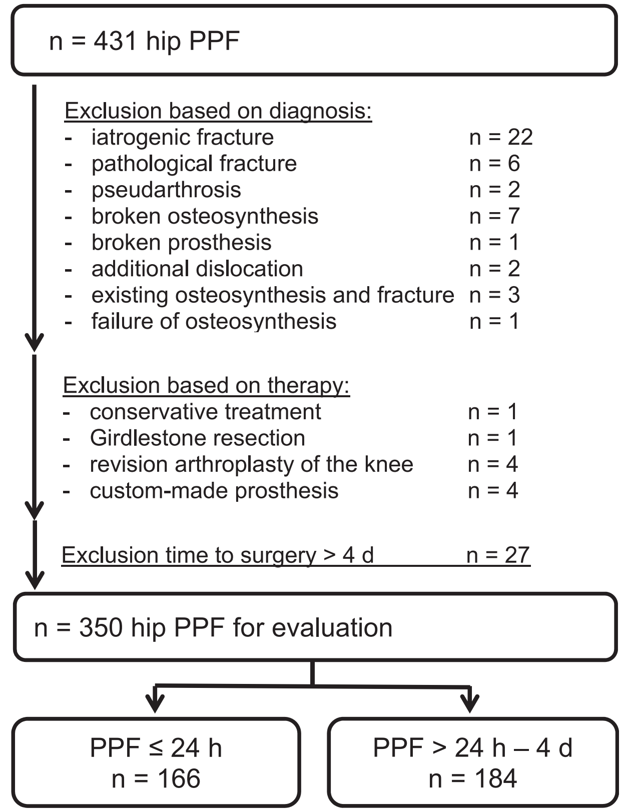

Fig. 1. Flowchart of the study population of hip periprosthetic femoral fractures (PPF).

Osteosynthesis was performed via the lateral approach, and revision arthroplasty was performed via the antero-lateral approach. All surgeries were planned digitally and reviewed during the indication meetings. Deviations from standard procedures were also determined. The concept of surgical therapy was consistent throughout the study period and implemented by senior consultants who have experience in both trauma surgery and arthroplasty. No delay in surgery was caused by the absence of a specialized surgeon.

Demographics

The mean age of the participants was 77 years (range, 33 to 97). Women were more frequently affected, with a proportion of 68.9% (241 of 350). In 87.1% (305 of 350) of patients, hip PPF was due to low-energy trauma.

Regarding baseline characteristics, the TTS ≤ 24 hours (n = 166) and TTS > 24 hours (n = 184) groups were comparable. There was no evidence of increased comorbidity in the TTS > 24 hours group. Preoperative glomerular filtration rate and Hb levels were significantly decreased, and preoperative C-reactive protein (CRP) levels significantly increased in patients who underwent surgery for > 24 hours. Patients on therapeutic plasma anticoagulation were more likely to undergo delayed surgery (Table 1).

The mean TTS was 12.3 hours (± 6.5) in the TTS ≤ 24 hours group and 52.6 hours (± 26.1) in the TTS > 24 hours group. The entire population had a mean TTS of 33.5 hours (± 28.0).

Regarding surgery-specific variables, Vancouver B2 fractures were more common in the TTS > 24 hours group, and Vancouver C fractures were more common in the TTS ≤ 24 hours group. The distribution of current implants was the same between the groups. According to fracture classification, revision arthroplasty occurred

Table 1
Baseline Characteristics.

Baseline Variables[a]	Time to Surgery		*P* Value
	≤24 h (n = 166)	>24 h-4 d (n = 184)	
Women, n (%)	119 (71.7)	122 (66.3)	.299[c]
Age (y), ⌀ (CI)	76 (73.8; 77.3)	77 (75.4; 77.7)	.150[b]
BMI (kg/m^2), ⌀ (CI)	26.6 (25.8; 27.4)	27.2 (26.4; 28.0)	.382[b]
ASA-Score [14], ⌀ (CI)	2.7 (2.6; 2.8)	2.8 (2.7; 2.8)	.131[b]
CHA_2DS_2VASc-Score [15], ⌀ (CI)	3.4 (3.2; 3.7)	3.7 (3.4; 4.0)	.165[b]
HAS-BLED-Score [16], ⌀ (CI)	2.7 (2.5; 2.9)	3.0 (2.8; 3.2)	.152[b]
Charlson-Score [17], ⌀ (CI)	2.3 (1.9; 2.7)	2.2 (1.9; 2.5)	.650[b]
GFR preoperative (mL/min), ⌀ (CI)	70.8 (67.6; 73.9)	64.3 (61.2; 67.5)	**.005**[b]
CRP preoperative (mg/dL), ⌀ (CI)	15.3 (11.6; 19.1)	23.3 (18.9; 27.8)	**.005**[b]
Hb at admission (g/dL), ⌀ (CI)	12.1 (11.8; 12.3)	11.8 (11.5; 12.0)	.128[b]
Hb preoperative (g/dL), ⌀ (CI)	12.1 (11.8; 12.3)	11.6 (11.3; 11.9)	**.019**[b]
Anticoagulation			
Acetylsalicylic acid, n (%)	49 (29.5)	54 (29.3)	.547[d]
Clopidogrel, n (%)	0 (0.0)	2 (1.1)	
Acetylsalicylic acid + Clopidogrel, n (%)	3 (1.8)	2 (1.1)	
Direct oral anticoagulants, n (%)	6 (3.6)	14 (7.6)	**.019**[d]
Coumarins, n (%)	9 (5.4)	25 (13.6)	
Heparin therapeutic dosage, n (%)	1 (0.6)	1 (0.5)	

Bold values indicate statistical significance (*P* < .05).
BMI, body-mass-index; ASA, American Society of Anesthesiologists; CHA_2DS_2VASc-Score, score for the risk of thromboembolism secondary to atrial fibrillation; HAS-BLED-Score, score to assess the risk of bleeding under anticoagulation for atrial fibrillation; GFR, glomerular filtration rate; CRP, C-reactive protein; Hb, hemoglobin.
[a] Data as number n and percentage (%) or as mean ⌀ and 95% confidence interval (CI). ⌀ and CI either dimensionless or in the unit specified.
[b] According to Mann-Whitney *U* test.
[c] Fisher's exact test.
[d] *Chi*-squared test.

Table 2
Surgery-Specific Variables.

Surgery-Specific Variables[a]	Time to Surgery		*P* Value
	≤24 h (n = 166)	>24 h-4 d (n = 184)	
Body side right, n (%)	88 (53.0)	100 (54.3)	.830[d]
Vancouver classification [18]			
A_G, n (%)	4 (2.4)	7 (3.8)	
B1, n (%)	32 (19.3)	44 (23.9)	
B2, n (%)	54 (32.5)	84 (45.7)	**.002**[e]
B3, n (%)	12 (7.2)	14 (7.6)	
C, n (%)	64 (38.6)	35 (19.0)	
Current femoral implant			
Standard stem cementless, n (%)	89 (53.6)	102 (55.4)	
Standard stem cemented, n (%)	58 (34.9)	63 (34.2)	.983[e]
Revision stem cementless, n (%)	15 (9.0)	15 (8.2)	
Revision stem cemented, n (%)	4 (2.4)	4 (2.2)	
Therapy			
Cable wire, n (%)	10 (6.0)	13 (7.1)	
Trochanter fixation plate, n (%)	4 (2.4)	8 (4.3)	
Locking plate, n (%)	78 (47.0)	52 (28.3)	
Double plate, n (%)	5 (3.0)	9 (4.9)	
RTHA standard stem cementless, n (%)	2 (1.2)	12 (6.5)	**.006**[e]
RTHA long stem cementless, n (%)	67 (40.4)	87 (47.3)	
RTHA long stem cemented, n (%)	0 (0.0)	2 (1.1)	
RTHA proximal femur replacement, n (%)	0 (0.0)	1 (0.5)	
Additive therapy			
acetabular cup exchange, n (%)	7 (4.2)	11 (6.0)	.691[e]
plate (trochanter or shaft), n (%)	9 (5.4)	8 (4.3)	
Duration of surgery (min), ⌀ (CI)	138 (130; 146)	140 (132; 148)	.769[c]
Transfer, n (%)	46 (27.7)	96 (52.2)	**.000**[d]
Time to surgery[b] (min), ⌀ (CI)	738 (678; 797)	3,154 (2,927; 3,381)	**.000**[c]

Bold values indicate statistical significance (*P* < .05).
RTHA, revision total hip arthroplasty.
[a] Data as number n and percentage (%) or as mean ⌀ and 95% confidence interval (CI). ⌀ and CI either dimensionless or in the unit specified.
[b] Time to surgery: including time in external hospitals.
[c] According to Mann-Whitney *U* test.
[d] Fisher's exact test.
[e] *Chi*-squared test.

Table 3
Outcome Variables.

Outcome Variables[a]	Time to Surgery		P Value
	≤24 h (n = 166)	>24 h-4 d (n = 184)	
Blood loss (mL), ⌀ (CI)	904 (785; 1,022)	1,003 (875; 1,130)	.242[b]
pRBCs intraoperative, ⌀ (CI)	0.9 (0.7; 1.0)	1.1 (0.9; 1.3)	**.035**[b]
Hb postoperative (g/dL), ⌀ (CI)	9.3 (9.1; 9.5)	9.3 (9.1; 9.5)	.813[b]
pRBCs in total, ⌀ (CI)	1.8 (1.5; 2.1)	2.7 (2.3; 3.1)	**.001**[b]
Inpatient stay (d), ⌀ (CI)	15.6 (14.7; 16.6)	17.9 (16.7; 19.2)	**.008**[b]
Operative complications, n (%)	27 (16.3)	28 (15.2)	.883[c]
General complications, n (%)	19 (11.4)	52 (28.3)	**.000**[c]
30-d mortality, n (%)	1 (0.6)	10 (5.5)	**.012**[c]
1-y mortality, n (%)	13 (8.3)	35 (20.5)	**.003**[c]

Bold values indicate statistical significance ($P < .05$).
pRBCs, packed red blood cells; Hb, hemoglobin.
[a] Data as number n and percentage (%) or as mean ⌀ and 95% confidence interval (CI). ⌀ and CI either dimensionless or in the unit specified.
[b] According to Mann-Whitney *U* test.
[c] Fisher's exact test.

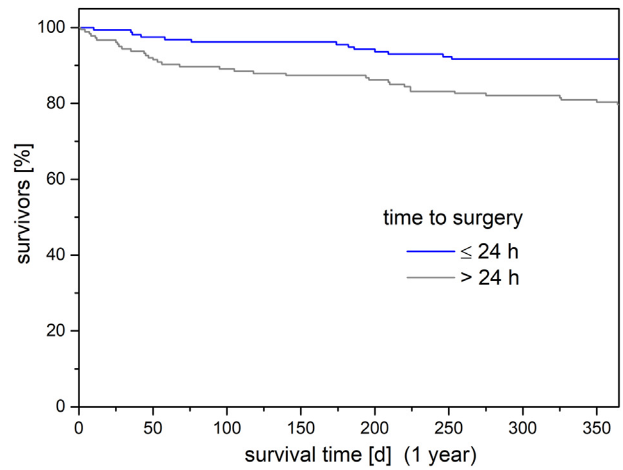

Fig. 2. Kaplan-Meier survival analysis.

more frequently in cases with TTS > 24 hours. The number of osteosynthesis was significantly higher in patients who had TTS ≤ 24 hours. The mean duration of surgery was the same in both groups (138 ± 53 versus 140 ± 55 minutes, $P = .769$). As expected, the number of transfers increased when TTS was > 24 hours (Table 2).

Data Analyses

Statistical analyses were performed using SPSS (version 24.0; SPSS Inc., Chicago, Illinois). Metric variables were tested for normal distribution using Kolmogorov–Smirnov tests. Mann-Whitney *U* tests were used to compare 2 independent samples that were non-normally distributed. Categorical or nominal data were analyzed using *Chi*-square or Fisher's exact tests. Two-sided significance tests were performed for all tests. Statistical significance was set at $P < .05$. Bivariate analyses were conducted to examine the dependence of the outcome parameters on all variables surveyed. Subsequently, significant variables in this analysis underwent Cox regressions for mortality rates and multivariable logistic regressions for complication rates. Survival analysis was performed using the Kaplan-Meier method or log-rank test.

Results

The 30-day mortality rate of the entire population was 3.2% (11 of 345), and the 1-year mortality was 14.7% (48 of 327). Both the 30-day and 1-year mortality rates were significantly higher in the delayed surgery group (Table 3), as illustrated by the Kaplan-Meier analysis of 1-year mortality (log-rank test, $P = .002$) (Figure 2). Cox regression analysis for mortality yielded a hazard ratio of 4.385 ($P < .001$) for TTS > 24 hours. Besides TTS > 24 hours, age, ASA, and Charlson score were identified as predictors of 1-year mortality in the cox regression (Table 4). Regardless of TTS, the 1-year mortality after osteosynthesis was 17.0% (28 of 165) and 12.3% (20 of 162) after revision arthroplasty; this difference was not statistically significant ($P = .275$). The therapy also showed no influence on outcome parameters in the regression analysis.

The incidence of operative complications was similar in both groups (16.3 versus 15.2%; $P = .883$). In contrast, general complications occurred significantly more frequently in the TTS >24 hours group than in the TTS ≤ 24 hours group (11.4 versus 28.3%; $P < .001$) (Table 3). This resulted in an odds ratio (OR) of 2.798 ($P = .001$) in the multivariable logistic regression (Table A.1). Additionally, age, Charlson score, and inpatient stay revealed a significant correlation with general complications in this analysis. Surgical complications only correlated with inpatient stay (OR 1.060, $P = .001$) in the regression analysis. Table A.2 in the appendix displays the distribution of specific complications between both groups.

Regarding the secondary outcome parameters, a TTS >24 hours resulted in a 2.3-day longer inpatient stay and a higher transfusion rate. In contrast, intraoperative blood loss and postoperative Hb levels were not significantly different between the 2 groups.

Discussion

This monocentric study examined the effect of TTS on complication and mortality rates. The hypothesis of the study was confirmed both in the group comparison (TTS < 24 hours versus TTS > 24 hours) and in the regression analysis for the outcome parameters. For patients who had hip PPF TTS > 24 hours, general complication and mortality rates increased.

Comparison to HF

The baseline characteristics of the included participants and those in other studies on hip PPF [2,3] are comparable to those of

Table 4
Predictors of 1-Year Mortality.

Variables[a]	Cox Regression	
	P Value	HR (CI)
Age	**.000**	1.103 (1.052; 1.155)
ASA-Score	**.023**	3.167 (1.172; 8.557)
CHA_2DS_2VASc-Score	.050	0.789 (0.623; 1.000)
Charlson-Score	**.000**	1.367 (1.212; 1.542)
GFR	.472	0.995 (0.982; 1.008)
CRP	.679	0.998 (0.988; 1.008)
Hb at admission	.722	0.970 (0.822; 1.145)
Direct oral anticoagulants	.535	1.357 (0.517; 3.566)
Coumarins	.300	1.550 (0.677; 3.551)
TTS >24 h	**.000**	4.385 (2.084; 9.226)

Bold values indicate statistical significance ($P < .05$).
HR, hazard ratio; CI, 95% confidence interval; ASA, American Society of Anesthesiologists; CHA_2DS_2VASc-Score, score for the risk of thromboembolism secondary to atrial fibrillation; GFR, glomerular filtration rate; CRP, C-reactive protein; Hb, hemoglobin; TTS, time to surgery.
[a] All other variables from Tables 1 through 3 were found not significant in the bivariate analysis as predictors for 1-y mortality.

patients who have HF. The mean patient age in studies on HF was 80 [4], that for patients who had hip PPF was 80 [2], and 77 years (± 10.7) in this study, respectively. Patients who had hip PPF and HF showed a similar sex distribution, with approximately 70% women. The proportion of multimorbid patients was high in both fracture types (mean Charlson score in the present study, 2.2 ± 2.3). Considering the outcome criteria, the present study (14.6%, 48 of 327), as well as other studies on patients who had hip PPF (11.0% [13]; 13% [24]; 13.8% [25]), showed a lower 1-year mortality than those who had HF (20.5% [4], 20% [2010s] [26]). The reason for this result remains unclear. Higher preoperative mobility and better cognitive status were postulated as the causes by Griffiths et al. [27]. Consistent with the results of existing HF studies [4,5], our study on hip PPF showed that TTS has a significant impact on mortality and complication rates.

Time to Surgery

For a differentiated analysis of the influence of TTS on mortality and complication rates, we categorized the patients into 2 comparison groups. The decreased preoperative glomerular filtration rate in the TTS > 24 hours group can be explained by volume deficiency [28]. This is caused by prolonged periods of fasting or insufficient fluid intake during the waiting period, as well as blood loss due to unreduced fractures. Accordingly, significantly lower preoperative Hb levels were observed in the patients who had prolonged TTS (Table 1). An increase in CRP levels with delayed surgery may be caused by infection (eg, pneumonia) in addition to trauma. Bivariate regression analysis identified preoperative CRP level (OR 1.01, $P = .043$) and Hb level (OR 0.77, $P = .003$) as predictors of 1-year mortality. However, they were not significant in the multivariable regression. For HF, these parameters have been shown to be risk factors [29,30].

The number of patients treated with direct oral anticoagulants or coumarins was significantly higher in the TTS > 24 hours group. For HF, it has been shown that minimally invasive procedures are safe within 24 hours regardless of anticoagulation [31]. In the case of hip PPF, it must be considered that surgical treatment is usually more complex and that more invasive approaches are required. Therefore, the duration of surgery was longer (139 versus 102 minutes [4]) and intraoperative blood loss was more (956 versus 300 mL [31]). Consequently, a reduction in the effect of anticoagulants was awaited unless minimally invasive osteosynthesis was possible.

In addition to the complexity and invasiveness of the surgery, poor familiarity with the implants among the nursing staff outside regular working hours is a possible reason why Vancouver B2 fractures and corresponding revision arthroplasty occurred more frequently in the TTS > 24 hours group.

It is important to emphasize that the aforementioned variables—anticoagulation, fracture pattern, and therapy—had no influence on the outcome parameters in the regression analysis.

Regarding secondary outcome parameters, the TTS > 24 hours group showed comparable blood loss, but a higher transfusion rate than the TTS ≤ 24 hours group. In addition, the preoperative Hb level was significantly lower in the TTS > 24 hours group. Therefore, it can be concluded that significant blood loss occurs with delayed surgery due to the unprovided fracture.

Comparison of the groups showed an obvious advantage in terms of lower mortality and reduction of general complications in cases with TTS ≤ 24 hours. Despite complex care, no increase in operative complications was observed in the present setting because of timely surgery.

Because a transfer is expected to be associated with a longer TTS (Table 2), an organizational structure (eg, telemetric transmission of reports; assigned centers) that ensures prompt transfer and, thus, a short TTS should be provided. It remains to be mentioned that timely care reduces inpatient length of stay and thus treatment costs.

Comparison to Other Studies

In the current literature, few studies have examined the effect of TTS on patients who have hip PPF. While some studies have demonstrated an effect of TTS on outcomes [12,13,27,32,33], others have not detected this correlation [9–11,25,34,35]. This contradiction is partly due to methodological reasons. In studies in which no effect of TTS on hip PPF was demonstrated, the mean TTS was usually long (> 3 days) [9–11]. According to the study results on HF, a short TTS is necessary to achieve a positive effect on outcomes. Consistently, an effect on patient outcomes can be demonstrated in studies on hip PPF with a shorter mean TTS [12,13]. Similarly, a meta-analysis of studies on TTS in patients who have PPF showed a reduction in mortality and complications associated with early surgery [33]. It is likely that a TTS ≤ 24 hours cannot be achieved generally because of the present supply structure. The need for transfer to centers where complex operations can be performed prevents timely care. Only Boddapati et al. [12] dichotomously divided their data using a TTS of 24 hours as a cutoff.

In addition, in the case of transfers, the time spent outside the destination hospital was not considered in the calculation of TTS. In multicenter studies, this information was probably not available [10,12,35]. In monocentric studies, time in other hospitals was usually not provided [9,13,27], or TTS was defined as the time from admission to surgery [25,34]. A limit for the TTS was not specified in any of the aforementioned hip PPF studies. Presumably, this was done to avoid further reductions in the already small sample size. However, the crucial influenceable factors that affect TTS—treatment of concomitant diseases and organizational reasons—were no longer considered relevant after a longer period. Accordingly, studies on HF excluded patients who had very long TTS [4,5].

Another limitation of existing studies on hip PPF is the sample size. To our knowledge, the largest monocentric study to date included 203 patients [25]. The largest multicenter study included 857 patients from more than 600 participating centers [12]. Statistically, this results in an average of less than 2 cases per center [12,35], suggesting great heterogeneity in surgical care and limiting its power. Furthermore, even in monocentric surveys, the type of surgical care was often not specified [9,10,25,27,34]. The combined analysis of hip and knee PPF [13,34] does not seem reasonable. These are different fracture types with different patient characteristics [36]. For example, the osteosynthesis rates are higher in knee PPF than in hip PPF [37]. Patients who have iatrogenic fractures or fractures occurring shortly after hip arthroplasty were not excluded in many studies [9,10,25,34,35]. However, their inclusion results in confounders. They are often healthier patients who have been medically prepared for the previous elective surgery and have already been hospitalized. This influences both the TTS and the outcome criteria.

Considering the aforementioned limitations, the following advantages of our study should be noted. To date, to our knowledge, this is the largest monocentric study on TTS in hip PPF. The mean TTS was 1.4 days. A dichotomous division of cases, with a TTS of 24 hours as a cutoff, was feasible with an adequate group size. For this cutoff, mortality and complication rates within 1 year were analyzed for the first time. The TTS was recorded to the minute. An essential aspect of TTS evaluation was addressed by taking into account the time spent outside the destination hospital. The surgical treatment scheme was described in detail and remained constant throughout the study period. All senior surgeons were equally experienced in trauma surgery and revision arthroplasty.

The potential limitations of the study included its retrospective nature and associated level of evidence. The authors themselves performed operations. A bias would, therefore, be conceivable. The confounding factor of sicker patients being operated on later, thus affecting both TTS and outcome parameters, was largely excluded from this study. Both groups had the same scores regarding concomitant diseases. However, frailty was not recorded. Further differentiation of TTS, for example, on a daily basis or additional differentiation according to therapy, was not performed. The resulting groups would have been too small. Although the number of patients was limited, a statistically and clinically relevant correlation was found between the main variable, TTS, and 1-year mortality, indicating an adequate sample size. Due to the monocentric survey, transferability is limited. Not all centers have the corresponding prerequisites for surgical care. Functional outcomes were not investigated.

Conclusions

Based on the results of this study, timely surgery is necessary for hip PPF. Patients who experience prolonged TTS, for example, due to the complexity of the surgery or the use of anticoagulants, require special attention because of the increased complication rates and mortality. Similar to HF, guidelines for care are needed for hip PPF to improve the quality of care. Structures for expeditious transfer to centers that can ensure a low TTS should be developed. Verification through registry studies involving several thousands of patients is desirable.

CRediT authorship contribution statement

Christian Wulbrand: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Bernd Füchtmeier:** Supervision. **Markus Weber:** Writing – review & editing, Validation, Formal analysis. **Christoph Eckstein:** Writing – review & editing. **Alexander Hanke:** Writing – review & editing, Validation, Formal analysis. **Franz Müller:** Writing – review & editing, Validation, Supervision, Formal analysis, Conceptualization.

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Appendix

Table A.1
Predictors for General Complications.

Variables[a]	Multiple Logistic Regression	
	P Value	HR (CI)
Age	**.008**	1.049 (1.012; 1.087)
ASA-Score	.374	1.401 (0.666; 2.945)
CHA_2DS_2VASc-Score	.487	1.101 (0.840; 1.443)
HAS-BLED-Score	.892	0.974 (0.661; 1.435)
Charlson-Score	**.019**	1.145 (1.023; 1.281)
GFR	.111	1.014 (0.997; 1.031)
Direct oral anticoagulants	.282	0.510 (0.149; 1.740)
Coumarins	.081	2.230 (0.906; 5.490)
Inpatient stay	**.002**	1.056 (1.020; 1.094)
TTS >24 h	**.001**	2.798 (1.506; 5.198)

Bold values indicate statistical significance ($P < .05$).
HR, hazard ratio; CI, 95% confidence interval; ASA, American Society of Anesthesiologists; CHA_2DS_2VASc-Score, score for the risk of thromboembolism secondary to atrial fibrillation; GFR, glomerular filtration rate; TTS, time to surgery.
[a] All other variables from Tables 1 through 3 were found not significant in the bivariate analysis as predictors for 1-y mortality.

Table A.2
Specific Complications.

Specific Complications	Time to Surgery	
	≤24 h	>24 h-4 d
General Complications		
Nosocomial pneumonia, n (%)	2 (1.2)	8 (4.3)
Apoplexy, n (%)	0 (0.0)	3 (1.3)
Thromboembolic events, n (%)	6 (3.6)	6 (3.3)
Urinary tract infection, n (%)	7 (4.2)	15 (8.2)
Renal failure, n (%)	0 (0.0)	3 (1.6)
Delirium, n (%)	3 (1.8)	10 (5.4)
Exitus lethalis during inpatient stay, n (%)	1 (0.6)	7 (3.8)
Operative complications		
Implant fracture, n (%)	6 (3.6)	2 (1.1)
Failure of osteosynthesis, n (%)	3 (1.8)	5 (2.7)
Pseudarthrosis, n (%)	1 (0.6)	0 (0.0)
Prosthesis sintering/loosening, n (%)	4 (2.4)	7 (3.8)
Dislocation, n (%)	4 (2.4)	4 (2.2)
Fracture, n (%)	2 (1.2)	1 (0.5)
Infection, n (%)	3 (1.8)	4 (2.2)
Hematoma, n (%)	4 (2.4)	4 (2.2)
Nerve damage, n (%)	0 (0.0)	1 (0.5)