■ HIP

Primary total hip arthroplasty after prior osteosynthesis versus osteotomy

DISTINCT RISK PROFILES AND THE MODIFYING EFFECT OF FEMORAL FIXATION

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Aims

To compare outcomes after primary total hip arthroplasty (THA) following prior ipsilateral osteosynthesis with prior ipsilateral osteotomy, and to assess whether femoral fixation modifies risk.

Methods

Using the German Arthroplasty Registry (EPRD; 2012 to 2024), two 1:1 matched analyses were performed: prior osteosynthesis versus no prior surgery (8,643 pairs) and prior osteotomy versus no prior surgery (5,569 pairs), matched on age, sex, BMI category, and Elixhauser score. Kaplan-Meier and Cox regression were used, censoring at death, with adjustment for femoral fixation (cemented, cementless, hybrid, reverse-hybrid).

Results

After prior osteosynthesis, hazards were higher for revision (HR 6.93 (95% CI 6.07 to 7.92), periprosthetic femoral fracture (PFF; HR 17.22 (95% CI 12.28 to 24.15)), and infection (HR 3.87 (95% CI 3.05 to 4.91)) compared with controls (all $p < 0.001$); cemented and hybrid fixation had lower revision and PFF hazards than cementless fixation. After prior osteotomy, revision (HR 2.30 (95% CI 1.89 to 2.80)) and dislocation (HR 9.43 (95% CI 4.55 to 19.56)) hazards were higher; PFF and infection were not significant. Reverse-hybrid fixation was associated with higher revision (HR 2.01 (95% CI 1.27 to 3.19)) and infection (HR 3.71 (95% CI 1.71 to 8.06)) hazards than cementless fixation.

Conclusion

Prior osteosynthesis denotes a high-risk, conversion-type THA scenario; cemented-based constructs were associated with lower PPF and revision hazards than cementless fixation. Prior osteotomy confers an intermediate risk profile, mainly driven by revision, dislocation, and loosening. Osteosynthesis and osteotomy histories should not be pooled in preoperative risk assessment before THA.

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Introduction

Primary total hip arthroplasty (THA) after previous hip surgery, either fracture fixation or osteotomy, is increasingly common.[1-3] These scenarios alter anatomy, soft-tissues, and bone quality, and may increase peri- and postoperative risk (hardware removal, scarring, canal morphology, osteoporosis).[4-6] A history of previous surgery influences operative strategy, particularly femoral component fixation.[5,7-9]

Cementless femoral components may increase early periprosthetic femoral fracture (PFF) risk in compromised bone or altered femoral morphology, whereas cemented fixation may reduce fracture risk but requires different considerations in deformity or with retained implants. Retained or removed hardware may introduce surgical complexity (stress risers, cortical defects, canal remodelling) and influence femoral preparation and implant choice. Dislocation risk may also be increased due to altered soft-tissue balance and abductor function. Existing evidence is heterogeneous: many studies pool osteotomy and osteosynthesis or are limited to small series, and it is difficult to draw conclusions that are useful for practice.[1,7,8]

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Table I. Baseline characteristics of the 1:1-matched primary total hip arthroplasty cohorts stratified by prior ipsilateral surgery (none vs osteosynthesis; none vs osteotomy). Index total hip arthoplasty procedural markers (hardware removal and revision-type femoral component use) are reported descriptively.

Characteristic	Prior osteosynthesis			Prior osteotomy		
	No	Yes	SMD	No	Yes	SMD
Patients, n	8,643	8,643		5,569	5,569	
Sex, n (%)			0			0
Female	6,322 (73.1)	6,341 (73.4)		3,700 (66.4)	3,699 (66.4)	
Male	2,321 (26.9)	2,302 (26.6)		1,869 (33.6)	1,870 (33.6)	
Mean age, yrs (SD)	70.8 (10.9)	71.7 (11.7)	-0.08	64.7 (12.3)	63.3 (13.9)	0.10
BMI, n (%)			0.09			0.01
Underweight, < 18.5 kg/m^2	109 (1.3)	190 (2.2)		62 (1.1)	62 (1.1)	
Normal, 18.5 to 24.99 kg/m^2	2,343 (27.1)	2,484 (28.7)		1,346 (24.2)	1,344 (24.1)	
Pre-obese, 25 to 29.99 kg/m^2	2,303 (26.6)	2,278 (26.4)		1,524 (27.4)	1,536 (27.6)	
Obese 1, 30 to 34.99 kg/m^2	1,167 (13.5)	1,133 (13.1)		878 (15.8)	874 (15.7)	
Obese 2, 35 to 39.99 kg/m^2	482 (5.6)	480 (5.6)		310 (5.6)	308 (5.5)	
Obese 3, ≥ 40 kg/m^2	210 (2.4)	207 (2.4)		109 (2)	106 (1.9)	
Missing	2,029 (23.5)	1,871 (21.6)		1,340 (24.1)	1,339 (24)	
Mean Elixhauser score (SD)	2.4 (4.7)	4.2 (6.9)	-0.31	1.1 (4.2)	1.2 (4.3)	-0.01
Fixation, n (%)			0.23			0.03
Cemented	809 (9.4)	1,059 (12.3)		304 (5.5)	306 (5.5)	
Cementless	6,070 (70.2)	5,407 (62.6)		4,447 (79.9)	4,421 (79.4)	
Hybrid	1,662 (19.2)	1,803 (20.9)		718 (12.9)	718 (12.9)	
Reverse-hybrid	102 (1.2)	374 (4.3)		100 (1.8)	124 (2.2)	
Type of arthroplasty, n (%)			0.10			0
Cemented component	2,471 (28.6)	2,862 (33.1)		1,022 (18.4)	1,024 (18.4)	
Cementless component	6,172 (71.4)	5,781 (66.9)		4,547 (81.6)	4,545 (81.6)	
Missing	0 (0)	0 (0)		0 (0)	0 (0)	
Revision-type femoral component, n (%)	6 (0.1)	648 (7.5)	0.40	8 (0.1)	69 (1.2)	0.13
Hardware removal, n (%)	4 (0.0)	1,816 (21.0)	0.73	6 (0.1)	116 (2.1)	0.19

SMD, standardized mean difference.

In this study, we used the German Arthroplasty Registry (Endoprothesenregister Deutschland; EPRD, 2012 to 2024) to compare patients undergoing THA in the setting of previous osteosynthesis, and those with previous osteotomy, with patients who had no history of previous surgery. We used time-to-event analyses for revision, mortality, periprosthetic fracture, aseptic loosening, and infection and adjustment for fixation method. We aimed to quantify the impact of the specific prior procedure (osteosynthesis vs osteotomy) on outcomes after primary THA and whether choices made in femoral fixation modifies risk. Recent EPRD evidence suggests distinct risk profiles after prior osteosynthesis versus osteotomy, but early hazard patterns and clinically interpretable absolute risks in matched cohorts remain unclear.[10] Our hypothesis was that, when compared with matched primary THAs without prior surgery, prior osteosynthesis is associated with substantially increased risks (revision, PFF, loosening, dislocation, infection, and mortality), whereas prior osteotomy shows moderate increases at most.[5,6,9,11,12]

Methods

Study design and data source. We conducted a retrospective, registry-based cohort study using the EPRD. Elective primary THAs performed between 12 November 2012 and 28 March 2024 were included. The EPRD integrates statutory health insurance billing records, a manufacturer-maintained implant product database, and electronic case reports from participating hospitals; it captures approximately 70% of primary THA procedures performed in Germany (around 75% since 2022), and enables near-complete follow-up via linked insurance data. As participation is voluntary and national coverage is incomplete, there is a possibility of selection bias and limited generalizability. National capture should be distinguished from longitudinal ascertainment within the captured statutory insurance cohort: linkage to insurer claims supports near-complete identification of revision procedures for included patients, even when a revision is performed at a hospital that does not actively submit case reports to the EPRD. Procedures and endpoints are cross-validated through linkage of hospital-reported cases with insurer accounting data (International Classification of Diseases of the World Health Organization, tenth revision (ICD-10)/Operationen- und Prozedurenschlüssel (OPS)). Implant component records are checked against the product library using automated plausibility checks (e.g. completeness and laterality/size mismatches) with feedback to participating hospitals, supporting accuracy and linkability within the registry. Coding followed OPS 2025 and ICD-10. Central ethical approval was obtained from the University of Kiel (D 473/11). Because non-capture occurs at the system level (non-participating institutions/insurance groups) rather than as missing fields within records, statistical imputation is not methodologically appropriate for addressing incomplete national coverage.

Patient selection. Adults undergoing elective primary THA, with side laterality recorded and documented history of prior ipsilateral osteosynthesis or osteotomy (vs no prior surgery),

were eligible. We excluded index revisions, hemiarthroplasty/resurfacing, acute fracture/emergency indications, and tumour indications for the index procedure, and cases with missing essential baseline variables or follow-up. After 1:1 matching, the cohorts comprised 8,643 pairs (prior osteosynthesis) and 5,569 pairs (prior osteotomy); study flow is shown in Supplementary Figure a.

Exposures and endpoints. The exposures were: documented ipsilateral prior osteosynthesis, or documented prior osteotomy. Endpoints were revision (first reoperation at the index hip involving implant exchange/removal for any cause), all-cause mortality, PFF, first aseptic loosening, first dislocation, and first infection at the index joint (ascertained from ICD-10/OPS coding in the registry/claims data; infections managed without a coded inpatient episode or reoperation may be underestimated). Death precludes the occurrence of non-fatal endpoints; therefore, for non-fatal endpoints we censored individuals at death (cause-specific approach). The complete ICD-10/OPS code lists used to define exposures and endpoints are provided in Supplementary Table iii. For descriptive/sensitivity purposes, PFF was additionally classified as intraoperative PFF (IOPFF; PFF coded during the index admission; a pragmatic proxy for perioperative events, including true intraoperative and very early postoperative fractures occurring before discharge) and postoperative PFF (POPFF; PFF coded after discharge from the index admission; post-discharge events). Because the EPRD does not provide postoperative day for complications, this coding-timestamp-based approximation cannot fully distinguish true intraoperative fractures from very early postoperative fractures occurring within the index admission. Hardware removal at the index THA and use of revision-type femoral components were extracted from registry records and the implant product library; these are reported descriptively (Table I).

Endpoints were analyzed separately and were not required to be mutually exclusive; a single admission or reoperation may carry multiple ICD-10/OPS codes and can therefore meet criteria for more than one endpoint.

Matching. For both comparisons, we applied 1:1 Mahalanobis matching (without arthroplasty) on age, sex, BMI category (including 'missing'), and the Elixhauser comorbidity index.[13] Covariate balance was assessed using standardized mean differences (SMD; imbalance defined as > 0.10). The femoral fixation method was not included in the matching and was therefore adjusted for in the Cox regression, along with any covariates that remained imbalanced post-match.

Statistical analysis. Descriptive data are reported as mean (SD) for continuous variables and n (%) for categorical variables. Time-to-event analyses employed Kaplan-Meier curves with log-rank tests. To aid clinical interpretation alongside hazard ratios, absolute event rates were also reported as Kaplan-Meier failure estimates (1−S(t)) with 95% CIs at prespecified timepoints (one, two, five, and eight years) and are provided in the Supplementary Tables i and ii. Time-to-event was measured from the date of the index primary THA. Events recorded during the index admission (including same-day events) may therefore occur at/near time zero and can appear as an early step in Kaplan-Meier failure plots, particularly when follow-up time is displayed in years. Associations were estimated using Cox proportional hazards models adjusted a priori for age, sex, BMI category (including 'missing'), Elixhauser score, and femoral fixation strategy (cemented, cementless, hybrid, reverse-hybrid). Given sparse events for some endpoints, the covariate set was pre-specified and kept parsimonious (no automated variable selection). For non-fatal endpoints, we used cause-specific Cox models and Kaplan-Meier analyses, censoring individuals at death. Results are presented as hazard ratios (HRs) with 95% CIs. Reference categories were defined as no prior ipsilateral surgery for the exposure variable (no prior osteosynthesis/osteotomy) and cementless fixation for femoral fixation; thus, fixation hazard ratios represent comparisons with cementless fixation. All tests were two-sided with $\alpha = 0.05$. Analyses were performed in R v. 4.2 (R Foundation for Statistical Computing, Austria).

Results

Study cohorts and baseline characteristics. Two matched analyses were performed: THA following prior osteosynthesis compared with no prior osteosynthesis, and THA following prior osteotomy compared with no prior osteotomy (Table I).

In the osteosynthesis analysis, the matching variables (age, sex, and BMI category) were well balanced by design (Table I), while the comorbidity burden (Elixhauser score) remained higher in the prior osteosynthesis group. Fixation strategy differed, with greater use of cemented and hybrid constructs after osteosynthesis. Revision-type femoral components and registry-recorded hardware removal at the time of THA were more frequent after osteosynthesis.

In the osteotomy analysis, baseline characteristics were well balanced for the matching variables (Table I). Cementless fixation predominated in both groups, with relatively small differences in fixation distribution. Hardware removal at the time of THA was uncommon.

Absolute event patterns. Kaplan-Meier failure curves are shown in Figures 1 and 2. Following prior osteosynthesis, curves separated early for revision and periprosthetic femoral fracture and remained divergent for the other endpoints. These early steps reflect events recorded during the index admission (including intraoperative complications and same-day reoperations) and should be interpreted as perioperative events rather than late failures. Following prior osteotomy, separation was most evident for revision, whereas the other endpoints showed less divergence over time. Absolute risks at clinically relevant timepoints are provided in Supplementary Tables i and ii.

Multivariable analysis. Adjusted hazard ratios are presented in Table II. In all Cox models, cementless fixation was the reference category for fixation type, and the 'no prior procedure' cohort was the reference for exposure.

Osteosynthesis cohort. Prior osteosynthesis was independently associated with increased hazards of revision, mortality, periprosthetic femoral fracture, aseptic loosening, dislocation, and infection (all statistically significant; Table II). Within this cohort, cemented and hybrid fixation were associated with lower hazards of revision and periprosthetic femoral fracture compared with cementless fixation.

Osteotomy cohort. Prior osteotomy was independently associated with increased hazards of revision, aseptic loosening, and

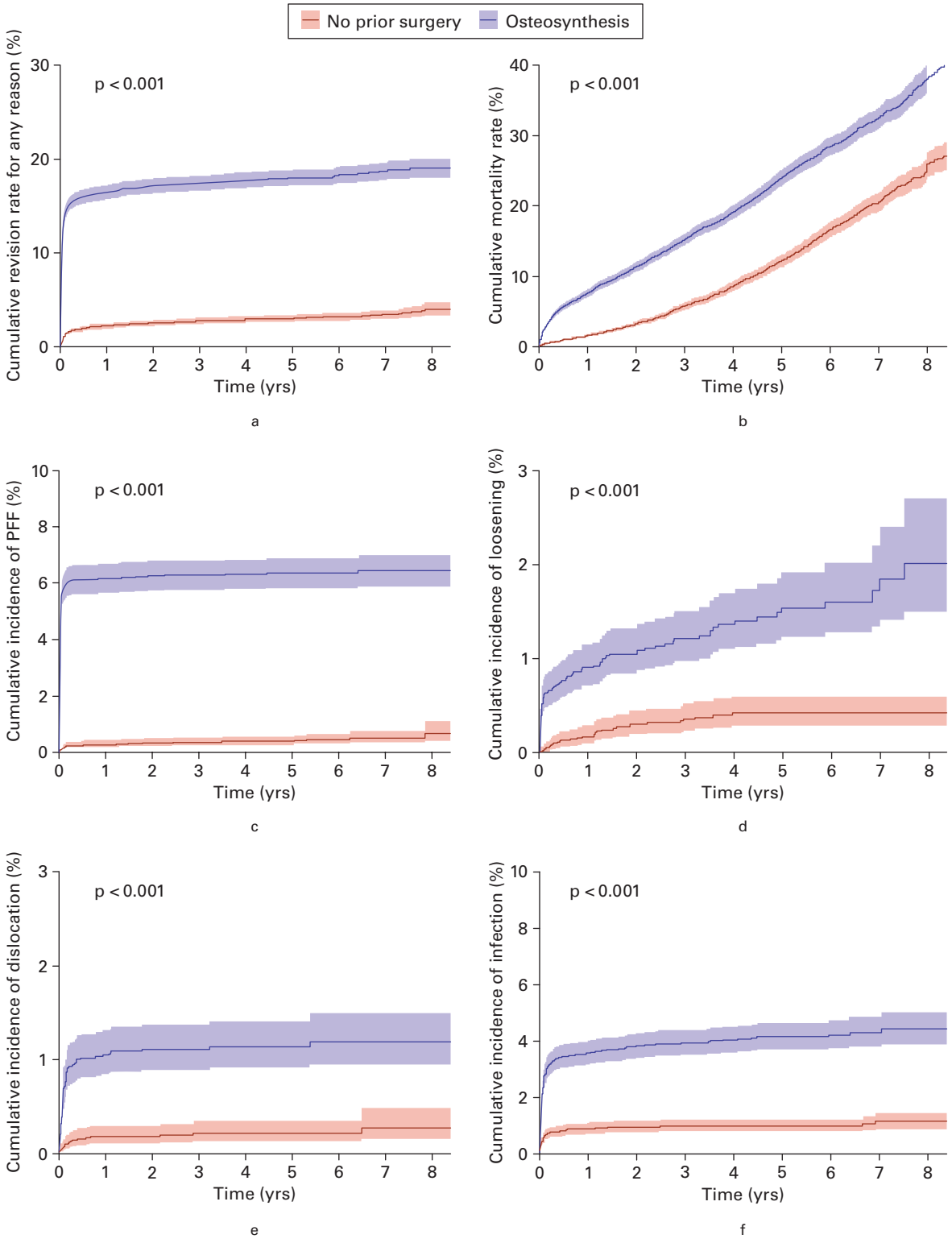

Fig. 1

Kaplan-Meier failure curves (1–S(t)) after primary total hip arthroplasty in 1:1 matched cohorts comparing prior osteosynthesis with no prior surgery. Panels show a) revision for any reason, b) mortality, c) periprosthetic femoral fracture (PFF), d) aseptic loosening, e) dislocation, and f) infection. Shaded bands indicate 95% CIs; p-values are from log-rank tests. For non-fatal endpoints, individuals were censored at death. Events recorded during the index admission (including same-day events) may appear at/near time zero.

Table II. Adjusted hazard ratios for revision, mortality, periprosthetic femoral fracture (PFF), aseptic loosening, dislocation, and infection by exposure and femoral fixation type (multivariable Cox regression). Cementless fixation was the reference category for fixation type.

Outcome	Exposure	HR (95% CI)	p-value*
Osteosynthesis cohort			
Revision	Osteosynthesis	6.93 (6.07 to 7.92)	< 0.001
Revision	Fixation cemented	0.40 (0.33 to 0.49)	< 0.001
Revision	Fixation hybrid	0.39 (0.33 to 0.45)	< 0.001
Revision	Fixation reverse-hybrid	0.81 (0.64 to 1.03)	0.091
Mortality	Osteosynthesis	2.04 (1.89 to 2.21)	< 0.001
Mortality	Fixation cemented	3.79 (3.45 to 4.16)	< 0.001
Mortality	Fixation hybrid	1.97 (1.80 to 2.17)	< 0.001
Mortality	Fixation reverse-hybrid	2.70 (2.28 to 3.21)	< 0.001
PFF	Osteosynthesis	17.22 (12.28 to 24.15)	< 0.001
PFF	Fixation cemented	0.05 (0.02 to 0.12)	< 0.001
PFF	Fixation hybrid	0.12 (0.08 to 0.19)	< 0.001
PFF	Fixation reverse-hybrid	0.46 (0.28 to 0.76)	0.002
Aseptic loosening	Osteosynthesis	4.52 (2.97 to 6.90)	< 0.001
Aseptic loosening	Fixation cemented	0.48 (0.23 to 0.98)	0.044
Aseptic loosening	Fixation hybrid	0.71 (0.45 to 1.13)	0.150
Aseptic loosening	Fixation reverse-hybrid	0.57 (0.18 to 1.80)	0.340
Dislocation	Osteosynthesis	4.47 (2.76 to 7.23)	< 0.001
Dislocation	Fixation cemented	2.21 (1.37 to 3.57)	0.001
Dislocation	Fixation hybrid	0.91 (0.54 to 1.55)	0.730
Dislocation	Fixation reverse-hybrid	1.78 (0.77 to 4.15)	0.180
Infection	Osteosynthesis	3.87 (3.05 to 4.91)	< 0.001
Infection	Fixation cemented	0.86 (0.62 to 1.19)	0.350
Infection	Fixation hybrid	0.74 (0.56 to 0.97)	0.028
Infection	Fixation reverse-hybrid	1.40 (0.90 to 2.19)	0.140
Osteotomy cohort			
Revision	Osteotomy	2.30 (1.89 to 2.80)	< 0.001
Revision	Fixation cemented	1.31 (0.91 to 1.87)	0.140
Revision	Fixation hybrid	0.94 (0.71 to 1.25)	0.680
Revision	Fixation reverse-hybrid	2.01 (1.27 to 3.19)	0.003
Mortality	Osteotomy	0.87 (0.76 to 1.00)	0.047
Mortality	Fixation cemented	4.46 (3.71 to 5.36)	< 0.001
Mortality	Fixation hybrid	2.88 (2.44 to 3.42)	< 0.001
Mortality	Fixation reverse-hybrid	2.53 (1.76 to 3.62)	< 0.001
PFF	Osteotomy	1.46 (0.75 to 2.81)	0.260
PFF	Fixation cemented	0.00 (0.00 to Inf)	1.000
PFF	Fixation hybrid	0.58 (0.18 to 1.88)	0.360
PFF	Fixation reverse-hybrid	2.39 (0.57 to 9.98)	0.230
Aseptic loosening	Osteotomy	2.13 (1.21 to 3.74)	0.008
Aseptic loosening	Fixation cemented	0.00 (0.00 to Inf)	1.000
Aseptic loosening	Fixation hybrid	0.78 (0.33 to 1.81)	0.560
Aseptic loosening	Fixation reverse-hybrid	0.77 (0.11 to 5.59)	0.800
Dislocation	Osteotomy	9.43 (4.55 to 19.56)	< 0.001
Dislocation	Fixation cemented	2.00 (0.95 to 4.18)	0.067
Dislocation	Fixation hybrid	1.39 (0.76 to 2.53)	0.290
Dislocation	Fixation reverse-hybrid	1.90 (0.59 to 6.06)	0.280
Infection	Osteotomy	1.39 (0.94 to 2.04)	0.095
Infection	Fixation cemented	2.15 (1.14 to 4.05)	0.018
Infection	Fixation hybrid	1.18 (0.66 to 2.08)	0.580
Infection	Fixation reverse-hybrid	3.71 (1.71 to 8.06)	< 0.001

*Cox proportional hazards model.
HR, hazard ratio.

dislocation, while associations with periprosthetic fracture and infection were not statistically significant in the main models. Reverse-hybrid fixation was associated with higher hazards of revision and infection compared with cementless fixation, and cemented fixation was also associated with a higher hazard of infection.

Intraoperative and postoperative periprosthetic femoral fracture. Given the marked early postoperative increase in fracture incidence, periprosthetic femoral fractures were additionally analyzed as intraoperative (IOPFF) and postoperative (POPFF) events (Table III). Prior osteosynthesis was strongly associated with both IOPFF and POPFF, and cemented or hybrid fixation was associated with lower hazards compared with cementless fixation. Prior osteotomy was also associated with increased hazards of IOPFF and POPFF, whereas fixation type was not independently associated with fracture risk in this cohort. These IOPFF/POPFF categories reflect coding during the index admission compared with after discharge and should be interpreted as a register-based proxy rather than a definitive clinical adjudication of intraoperative versus postoperative fracture timing.

Discussion

This matched registry study distinguishes prior osteosynthesis from prior osteotomy as separate exposures before primary THA, and quantifies key outcomes while adjusting for fixation strategy. Our findings are consistent with the matched EPRD analysis by Wagener et al,[10] but extend previous work by analyzing osteosynthesis and osteotomy separately, which are often pooled.[1,2,7,8]

After prior osteosynthesis, pronounced early and overall risks were evident, with markedly increased hazards for revision, mortality, PFF, aseptic loosening, dislocation, and infection; the survival curves diverged early. Cementless femoral fixation further amplified the risks of revision and PFF.[4-6,8] By contrast, prior osteotomy showed a more selective pattern: revision, dislocation, and aseptic loosening were higher than in matched controls, whereas PFF and infection remained uncommon; fixation effects were inconsistent and constrained by sparse events. Absolute event risks to complement the HRs are provided in the Supplementary Tables i and ii.

Potential mechanisms may explain these findings. The distinction between intraoperative and postoperative PFF is clinically important and has been emphasized in large registry analyses. Lamb et al[14] showed that intraoperative PFF during primary THA, although uncommon, is associated with worse

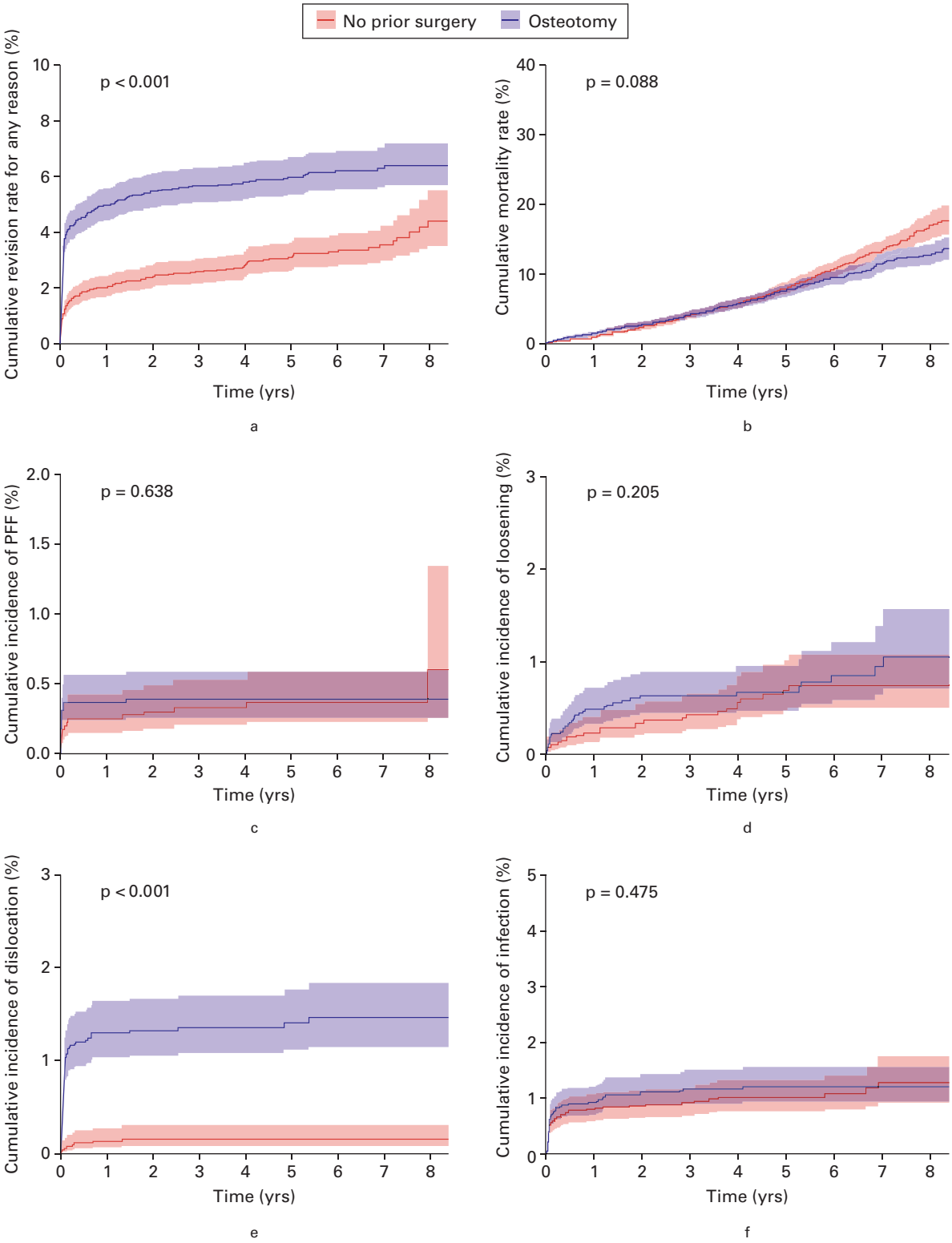

Fig. 2

Kaplan-Meier failure curves (1–S(t)) after primary total hip arthroplasty in 1:1 matched cohorts comparing prior osteotomy with no prior surgery. Panels show a) revision for any reason, b) mortality, c) periprosthetic femoral fracture (PFF), d) aseptic loosening, e) dislocation, and f) infection. Shaded bands indicate 95% CIs; p-values are from log-rank tests. For non-fatal endpoints, individuals were censored at death. Events recorded during the index admission (including same-day events) may appear at/near time zero.

Table III. Adjusted hazard ratios for intraoperative and postoperative periprosthetic femoral fracture, stratified by cohort (multivariable Cox regression). Cementless fixation was the reference category for fixation type.

Outcome	Exposure	HR (95% CI)	p-value*
Osteosynthesis cohort			
IOPPF	Osteosynthesis	29.4 (15.6 to 55.4)	< 0.001
IOPPF	Fixation cemented	0.09 (0.03 to 0.24)	< 0.001
IOPPF	Fixation hybrid	0.30 (0.20 to 0.46)	< 0.001
IOPPF	Fixation reverse-hybrid	0.83 (0.47 to 1.45)	0.510
POPPF	Osteosynthesis	25.6 (18.8 to 34.9)	< 0.001
POPPF	Fixation cemented	0.14 (0.10 to 0.22)	< 0.001
POPPF	Fixation hybrid	0.17 (0.13 to 0.22)	< 0.001
POPPF	Fixation reverse-hybrid	0.59 (0.42 to 0.83)	0.002
Osteotomy cohort			
IOPPF	Osteotomy	3.27 (1.06 to 10.0)	0.038
IOPPF	Fixation cemented	1.04 (0.14 to 7.94)	0.970
IOPPF	Fixation hybrid	0.44 (0.06 to 3.36)	0.430
IOPPF	Fixation reverse-hybrid	2.70 (0.35 to 20.5)	0.340
POPPF	Osteotomy	3.94 (2.56 to 6.07)	< 0.001
POPPF	Fixation cemented	0.84 (0.37 to 1.90)	0.670
POPPF	Fixation hybrid	0.71 (0.39 to 1.28)	0.250
POPPF	Fixation reverse-hybrid	1.44 (0.53 to 3.90)	0.480

*Cox proportional hazards model.
HR, hazard ratio; IOPFF, intraoperative periprosthetic femoral fracture; POPFF, postoperative periprosthetic femoral fracture.

implant survival and higher mortality. In conversion-type settings, intraoperative fractures may occur more frequently; for example, Selim et al[15] reported seven intraoperative fractures in 167 hips (4.2%) in conversion THA after previous hip fracture surgery. In our matched osteosynthesis cohort, registry-coded PFF events clustered early, consistent with a perioperative complication cluster. Because the EPRD does not provide postoperative day for complications, we could not apply a POD1 filter; instead, we classified PFF coded during the index admission as IOPFF (a pragmatic proxy for perioperative events, including true intraoperative and very early postoperative fractures occurring before discharge) and PPF coded after discharge as POPFF (post-discharge events; Supplementary Table iii). Methodological work from the UK has similarly highlighted that careful definition and linkage are needed to capture postoperative PFF treated with fixation rather than revision.[16]

Following osteosynthesis, there are often canal-narrowing sclerotic changes, cortical defects (screw holes), scarring, and residual stress-risers; the press-fit of a cementless femoral component generates additional hoop and wedge forces, a plausible mechanism for the marked susceptibility to PFF and downstream complications culminating in revision. Cementing can bridge defects, restore primary stability, and dampen hoop stress. The apparent mortality advantage of non-cemented strategies in our cohort likely reflects, at least in part, selection (cementing being used more often in older, comorbid patients); large registries generally show no clinically relevant differences in early mortality.[6–8,17,18]

Our findings align with registry data indicating that cementless femoral components, particularly in vulnerable cohorts, are associated with more PFF and often more revisions, without a consistent mortality disadvantage of cementing.[3-6,9,11,12] Specifically, Dutch registry data showed that among patients aged ≥ 80 years, mortality was comparable between cemented and cementless THA, whereas revision rates were higher with cementless fixation, aligning with our fixation-related revision signal.[8] Results from the Nordic registries likewise indicate similar early mortality for cemented compared with cementless approaches, supporting our interpretation that mortality differences in the EPRD likely reflect selection/confounding rather than fixation causality.[7] A large Swedish analysis reported more revisions and PFF with cementless fixation, but no relevant difference in early mortality, concordant with our risk model.[6] The American Joint Replacement Registry (AJRR) found a significantly higher PFF risk with cementless femoral fixation, reinforcing the strong PFF association observed in our sub-group with prior osteosynthesis.[3,5] Finally, Swedish data indicate that internal fixation of femoral neck fractures is frequently followed by conversion arthroplasty, underscoring the clinical vulnerability and 'conversion-type' character of the osteosynthesis-history population.[1]

Previous studies have typically treated 'previous surgery' as a composite category. Our separate analysis shows that osteosynthesis and osteotomy have different effects on outcome: a history of osteosynthesis is a dominant risk driver across all endpoints, whereas prior osteotomy demonstrates a narrower risk profile, with increases in revision, dislocation, and aseptic loosening but low absolute risks of PFF and infection. This distinction is operationally important (implant choice, perioperative planning, consent) and should refine perioperative management.[1,2,5-8,11]

From a practical standpoint, prior osteosynthesis should be approached as a conversion-type scenario. This warrants meticulous preoperative assessment, including imaging review and templating, to identify residual stress risers (e.g. screw holes), cortical defects, canal remodelling, and femoral deformity, and to tailor the surgical plan accordingly. In this setting, femoral fixation strategy is a key modifiable factor: our data show markedly higher early PFF and revision hazards with cementless fixation, whereas cemented (or hybrid fixation) strategies appear protective. These findings align with large registry reports showing increased PFF and, in several cohorts, higher revision risk with cementless femoral components, while cemented fixation can reduce PFF risk in older or vulnerable patients without a consistent early mortality penalty.[4-6,8,9,11,12] Risk communication and informed consent should therefore explicitly address the higher likelihood of early complications after prior osteosynthesis, and postoperative surveillance should be adapted to this higher-risk profile. Decisions regarding additional intraoperative fracture prevention measures and techniques to manage deformity (e.g. choice of femoral component geometry/length or modularity in complex femoral anatomy) should remain individualized based on intraoperative findings and surgeon judgement, and cannot be directly inferred from this observational registry analysis.

Strengths of this study include national registry coverage, two separate 1:1 matched comparisons, and a prespecified,

parsimonious modelling strategy with explicit adjustment for femoral fixation in all Cox models. For non-fatal endpoints, we used a cause-specific time-to-event approach with censoring at death. Several limitations inherent to registry-based research should, however, be considered. First, outcomes are obtained from administrative/registry coding (ICD-10/OPS) and may therefore be subject to incomplete capture and misclassification. This is particularly relevant for infection, as the registry does not provide clinical adjudication (e.g. established periprosthetic joint infection (PJI) definitions, microbiology, antibiotic duration, or severity), and infections managed conservatively without a coded inpatient episode or reoperation may not be captured; thus, our infection endpoint primarily reflects clinically significant infections recorded in claims/registry data. Second, the distinction between intraoperative and early postoperative PFF is based on administrative coding and the timing of coding (index admission vs subsequent admissions) rather than detailed operative reporting; misclassification and underrecording are therefore possible. Very early PFF (and related revisions) may be recorded at or near the index date and appear as early steps in Kaplan-Meier plots; these should be interpreted as perioperative events (index admission) rather than late fracture hazards. Third, residual confounding cannot be excluded (e.g. bone quality, femoral component design, cementing technique, surgical approach, and perioperative prophylaxis), and coding practices and thresholds for reoperation may vary between hospitals and over time. Although revision-type femoral components were documented and reported descriptively (Table I), their low prevalence precluded inclusion in the matching/adjustment models, and therefore a small residual confounding effect by femoral component type cannot be fully excluded. Fourth, event counts for PFF and loosening in the osteotomy comparison were low, resulting in imprecise estimates with wide confidence intervals. Finally, the EPRD dataset does not provide sufficiently reliable information to quantify the interval between the prior ipsilateral procedure (osteosynthesis/osteotomy) and subsequent THA; therefore, we could not distinguish acute conversions from remote events, and our estimates reflect outcomes across a heterogeneous range of intervals.

Registry completeness is an important limitation. The EPRD captures approximately 70% of arthroplasty procedures in Germany (around 75% since 2022), which is below the 80% threshold recommended by ISAR for national representativeness, which may introduce non-response (selection) bias and limit generalizability if participating centres and patients differ systematically from those not captured. National coverage is incomplete and may limit population-wide generalizability; however, within the included statutory insurance cohort, claims linkage supports near-complete ascertainment of revision procedures, reducing the risk of systematically missed revisions for the analyzed population. Data quality and linkability within the registry are supported by mandatory dual reporting (hospital case reports and statutory health insurer claims), pseudonymized patient identifiers enabling longitudinal linkage, automated plausibility/consistency checks (including implant library validation), and structured feedback to participating hospitals. Privately insured patients are not included in routine longitudinal follow-up, and smaller hospitals may be underrepresented; therefore, population-wide absolute incidence estimates should be interpreted with caution. However, comparative analyses within the captured statutory insurance cohort remain informative because revision ascertainment for included patients is supported by claims linkage, reducing the risk of systematically missed revisions within the analyzed population.

In conclusion, in practice, not all 'previously operated hips' are alike: prior osteosynthesis denotes a high-risk, early-complication, and PFF-prone scenario that is exacerbated by cementless fixation; cemented and hybrid fixation appear protective against PFF and revision compared with cementless fixation. Prior osteotomy carries an intermediate risk profile, with higher revision and dislocation risks than primary THA, but low absolute risks of PFF and infection. This distinction should guide implant selection, patient counselling, and follow-up.[4–6,9,11]

Take home message

- Osteosynthesis and osteotomy before total hip arthroplasty have distinct risk profiles and should not be pooled.
- After prior osteosynthesis, cemented or hybrid fixation was associated with lower revision and periprosthetic femoral fracture hazards than cementless fixation.

Supplementary material

Tables of absolute event risks after primary total hip arthroplasty in patients with prior osteosynthesis versus no prior osteosynthesis, and patients with prior osteotomy versus no prior osteotomy; ICD-10-GM and OPS code lists used for cohort selection, exposure definitions, and endpoint ascertainment; and a study flowchart.

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