■ TRAUMA

The risk of complications after hip fracture

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Aims

The risk of mortality after a hip fracture has been extensively investigated, but there is little high-quality information available dealing with the overall risk of complications. The aim of this study was to report the risk of complications in the first 120 days after a hip fracture.

Methods

This was a multicentre, prospective cohort study of patients aged > 60 years with a hip fracture, involving 77 hospitals in England, Wales, and Northern Ireland, between January 2015 and 2022. The primary outcomes of interest were mortality and surgery-specific and general complications, at 120 days postoperatively.

Results

A total of 24,523 patients with a hip fracture were enrolled. The 120-day risk of mortality was 12.4% (95% CI 12.0 to 12.8). The 120-day risks of surgery-specific complications were: for dislocation, 1.5% (95% CI 1.3 to 1.7); failure of fixation, 1.0% (95% CI 0.8 to 1.2); for peri-implant or periprosthetic fracture, 0.3% (95% CI 0.3 to 0.4); for reoperation for any indication, 2.7% (95% CI 2.5 to 2.9); and for surgical site infection, 3.4% (95% CI 3.2 to 3.6). The 120-day risks of general complications were: for acute kidney injury, 3.4% (95% CI 3.1 to 3.6); for the requirement of a blood transfusion, 7.0% (95% CI 6.7 to 7.3); for lower respiratory tract infection, 9.1% (95% CI 8.7 to 9.4); for urinary tract infection, 7.0% (95% CI 6.7 to 7.3); for cerebrovascular accident, 0.7% (95% CI 0.6 to 0.8); for myocardial infarction, 0.7% (95% CI 0.6 to 0.9); and for venous thromboembolism, 1.8% (95% CI 1.6 to 2.0).

Conclusions

Although the risk of mortality has declined in recent years, older patients with a hip fracture remain at a high risk of surgery-specific and general complications.

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Introduction

Older adults with a hip fracture are at a high risk of complications,[1,2] which lead to prolonged hospitalization, increased mortality, and higher healthcare and social care costs.[3–7] Complications may arise due to the patients' comorbidities and the nature of the injury itself or may be related to the type of operation, and can be influenced by the form of surgical treatment.[1] There is some uncertainty about the choice of operation,[8] which contributes to non-adherence to published guidelines, and substantial variation in clinical decision-making between hospitals and individual surgeons.[9]

While the risk of mortality in these patients has declined in recent years,[10] there is little high-quality information dealing with the risk of complications after a hip fracture.[11] In particular, few studies have compared the complication profiles of contemporary forms of orthopaedic treatment such as the sliding hip screw, cephalomedullary nail, cannulated screws, hemiarthroplasty, and total hip arthroplasty.[11] Establishing a benchmark for the complication rates after these procedures will facilitate the optimal design of hip fracture services and quantify the costs of associated surgery for the providers of healthcare. The identification of significant associations between the choice of operation and outcome will also inform future clinical trials.

The aim of this study was to describe the risk of complications after the treatment of a hip fracture and evaluate associations between the complications and the operations, which are commonly used in these patients.

Methods

The World Hip Trauma Evaluation (WHiTE) study was a multicentre, prospective observational

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Table I. Demographics of the patients in the World Hip Trauma Evaluation.

Characteristic	Overall	SHS	CMN	CS	HHA	THA
Patients, n	24,523	5,546	2,645	644	11,283	2,076
Mean age, yrs (SD)	82.9 (8.4)	83.1 (8.7)	82.6 (8.9)	79.1 (9.3)	84.2 (7.6)	74.9 (7.2)
Sex, n (%)						
Male	7,337 (29.9)	1,609 (29.0)	662 (25.0)	166 (25.8)	3,507 (31.1)	564 (27.2)
Female	17,186 (70.1)	3,937 (71.0)	1,983 (75.0)	478 (74.2)	7,776 (68.9)	1,512 (72.8)
Regular smoker, n (%)						
Yes	2,139 (8.7)	549 (9.9)	246 (9.3)	73 (11.3)	869 (7.7)	206 (9.9)
No	20,958 (85.5)	5,546 (84.6)	2,229 (84.3)	541 (84.0)	9,774 (86.6)	1,810 (87.2)
Missing	1,426 (5.8)	306 (5.5)	170 (6.4)	30 (4.7)	640 (5.7)	60 (2.9)
Weekly alcohol consumption, n (%)						
0 to 7 units	20,453 (83.4)	4,618 (83.3)	2,158 (81.6)	533 (82.8)	9,620 (85.3)	1,625 (78.3)
8 to 14 units	1,458 (5.9)	353 (6.4)	172 (6.5)	51 (7.9)	549 (4.9)	220 (10.6)
15 to 21 units	507 (2.1)	109 (2.0)	60 (2.3)	15 (2.3)	201 (1.8)	92 (4.4)
> 21 units	604 (2.5)	146 (2.6)	82 (3.1)	14 (2.2)	225 (2.0)	76 (3.7)
Missing	2,001 (8.2)	320 (5.8)	173 (6.5)	31 (4.8)	688 (6.1)	63 (3.0)
Diabetic, n (%)						
Yes	3,603 (14.7)	774 (14.0)	408 (15.4)	92 (14.3)	1,741 (15.4)	227 (10.9)
No	19,566 (79.8)	4,475 (80.7)	2,068 (78.2)	524 (81.4)	8,953 (79.3)	1,791 (86.3)
Missing	1,354 (5.5)	297 (5.4)	169 (6.4)	28 (4.3)	589 (5.2)	58 (2.8)
Renal failure, n (%)						
Yes	1,807 (7.4)	362 (6.5)	181 (6.8)	38 (5.9)	958 (8.5)	61 (2.9)
No	21,335 (87.0)	4,882 (88.0)	2,294 (86.7)	576 (89.4)	9,727 (86.2)	1,951 (94.0)
Missing	1,381 (5.6)	302 (5.4)	170 (6.4)	30 (4.7)	598 (5.3)	64 (3.1)
Cognitive impairment, n (%)						
Yes	7,761 (31.6)	1,621 (29.2)	638 (24.1)	117 (18.2)	4,469 (39.6)	57 (2.7)
No	15,541 (63.4)	3,688 (66.5)	1,868 (70.6)	489 (75.9)	6,365 (56.4)	1,942 (93.5)
Missing	1,221 (5.0)	237 (4.3)	139 (5.3)	38 (5.9)	449 (4.0)	77 (3.7)
ASA grade, n (%)						
I	453 (1.8)	114 (2.1)	41 (1.6)	31 (4.8)	80 (0.7)	181 (8.7)
II	5,527 (22.5)	1,278 (23.0)	636 (24.0)	226 (35.1)	2,019 (17.9)	1,126 (54.2)
III	13,545 (55.2)	3,062 (55.2)	1,469 (55.5)	293 (45.5)	6,816 (60.4)	625 (30.1)
IV	3,546 (14.5)	809 (14.6)	372 (14.1)	56 (8.7)	1,841 (16.3)	33 (1.6)
V	72 (0.3)	11 (0.2)	9 (0.3)	2 (0.3)	43 (0.4)	2 (0.1)
Missing	1,380 (5.6)	272 (4.9)	118 (4.5)	36 (5.6)	484 (4.3)	109 (5.3)
Fracture type, n (%)						
Femoral neck, undisplaced (B1)	1,647 (6.7)	427 (7.7)	17 (0.6)	466 (72.4)	537 (4.8)	129 (6.2)
Femoral neck, displaced (B3)	15,103 (61.6)	307 (5.5)	43 (1.6)	103 (16.0)	10,696 (94.8)	1,930 (93.0)
Trochanteric, simple (A1)	2,393 (9.8)	2,113 (38.1)	212 (8.0)	40 (6.2)	17 (0.2)	7 (0.3)
Trochanteric, unstable (A2)	3,408 (13.9)	2,475 (44.6)	871 (32.9)	28 (4.3)	25 (0.2)	3 (0.1)
Trochanteric, transtrochanteric (A3)	817 (3.3)	158 (2.8)	651 (24.6)	3 (0.5)	3 (0.0)	2 (0.1)
Subtrochanteric	929 (3.8)	64 (1.2)	847 (32.0)	4 (0.6)	3 (0.0)	4 (0.2)
Missing	226 (0.9)	2 (0.0)	4 (0.2)	0 (0.0)	2 (0.0)	1 (0.0)

CMN, cephalomedullary nail; CS, cannulated screws; HHA, hip hemiarthroplasty; SHS, sliding hip screw; THA, total hip arthroplasty.

cohort study in which data were collected relating to the assessment, treatment and recovery of a comprehensive cohort of patients with a hip fracture in England, Wales, and Northern Ireland.[12] All adults who presented with a hip fracture to any of the 77 participating NHS hospitals were eligible for inclusion. Exclusion criteria were adults aged < 60 years and those who were treated nonoperatively. Nonoperative treatment is unusual in the UK; almost all patients (98%) with a hip fracture are treated surgically.[13] On enrolment, patients were treated according to a single standardized care pathway based on the National Institute for Health and Care Excellence (NICE) Hip Fracture Guidelines (CG124).[14] All patients were followed up for 120 days after surgery using telephone interviews and/or postal questionnaires. Complications, as reported by the patient or their carers, were cross-referenced with their medical records from hospital and community databases.

The primary exposure was the operative treatment for a hip fracture, including operations performed for internal fixation such as the sliding hip screw, cephalomedullary nail, and cannulated screws, and arthroplasty such as the hip hemiarthroplasty and total hip arthroplasty.

A total of 24,523 patients were enrolled and complete follow-up was available for 22,228 (90.6%). A total of 8,835 patients underwent internal fixation, of whom 5,546 (22.6%) were treated with a sliding hip screw, 2,645 (10.8%) with a cephalomedullary nail, and 644 (2.6%) with cannulated

Table II. Absolute risk of complications 120 days after surgery for a hip fracture.

Outcome	Risk, % (95% CI)					
	Cohort	SHS	CMN	CS	HHA	THA
Mortality						
30 days	3.9 (3.6 to 4.1)	3.8 (3.3 to 4.3)	2.5 (1.9 to 3.1)	1.2 (0.4 to 2.1)	4.5 (4.1 to 4.9)	0.5 (0.2 to 0.8)
120 days	12.4 (12.0 to 12.8)	13.1 (12.2 to 14.0)	11.2 (10.0 to 12.4)	7.3 (5.3 to 9.3)	13.6 (12.9 to 14.2)	2 (1.4 to 2.6)
Surgery-specific complications						
Prosthesis dislocation						
30 days	0.9 (0.7 to 1.0)	N/A	N/A	N/A	0.8 (0.6 to 1.0)	0.8 (0.4 to 1.1)
120 days	1.7 (1.5 to 1.9)	N/A	N/A	N/A	1.4 (1.2 to 1.6)	2.1 (1.5 to 2.7)
Fixation failure						
30 days	0.3 (0.2 to 0.4)	0.2 (0.1 to 0.3)	0.2 (0.0 to 0.4)	1.3 (0.4 to 2.1)	N/A	N/A
120 days	1 (0.8 to 1.2)	0.7 (0.5 to 1.0)	1 (0.6 to 1.4)	2.9 (1.6 to 4.2)	N/A	N/A
Periprosthetic or peri-implant fracture						
30 days	0.2 (0.1 to 0.3)	0.1 (0.0 to 0.2)	0.3 (0.1 to 0.5)	0 (0.0 to 0.0)	0.3 (0.2 to 0.4)	0.1 (0.0 to 0.2)
120 days	0.3 (0.3 to 0.4)	0.2 (0.1 to 0.3)	0.7 (0.4 to 1.0)	0 (0.0 to 0.0)	0.4 (0.3 to 0.5)	0.1 (0.0 to 0.3)
Reoperation for any indication						
30 days	1.4 (1.2 to 1.5)	0.8 (0.6 to 1.0)	1 (0.7 to 1.4)	2.4 (1.2 to 3.5)	1.6 (1.4 to 1.9)	0.9 (0.5 to 1.3)
120 days	2.7 (2.5 to 2.9)	1.7 (1.4 to 2.0)	2.8 (2.2 to 3.4)	4.9 (3.2 to 6.5)	2.8 (2.5 to 3.1)	2.8 (2.1 to 3.5)
Revision surgery						
30 days	0.3 (0.3 to 0.4)	0.3 (0.1 to 0.4)	0.3 (0.1 to 0.5)	1.3 (0.5 to 2.2)	0.4 (0.3 to 0.5)	0.2 (0.0 to 0.4)
120 days	1 (0.9 to 1.1)	0.9 (0.6 to 1.1)	1.6 (1.1 to 2.1)	3.6 (2.1 to 5.0)	0.8 (0.6 to 0.9)	0.6 (0.3 to 1.0)
Reoperation for infection						
30 days	0.7 (0.6 to 0.8)	0.4 (0.2 to 0.6)	0.6 (0.3 to 0.9)	0.5 (0.0 to 1.0)	0.8 (0.7 to 1.0)	0.4 (0.1 to 0.6)
120 days	1.1 (1.0 to 1.2)	0.7 (0.5 to 0.9)	1.1 (0.7 to 1.5)	0.8 (0.1 to 1.5)	1.2 (1.0 to 1.4)	0.8 (0.4 to 1.1)
Surgical site infection (all)						
30 days	2.3 (2.1 to 2.5)	1.9 (1.5 to 2.2)	2.2 (1.7 to 2.8)	2 (0.9 to 3.0)	2.5 (2.2 to 2.8)	2 (1.4 to 2.6)
120 days	3.4 (3.2 to 3.6)	2.8 (2.4 to 3.3)	3.1 (2.4 to 3.7)	2.8 (1.5 to 4.0)	3.6 (3.3 to 4.0)	3.1 (2.4 to 3.8)
Surgical site infection (deep or organ space)						
30 days	0.9 (0.7 to 1.0)	0.7 (0.5 to 0.9)	0.9 (0.6 to 1.3)	0.6 (0.0 to 1.2)	0.9 (0.8 to 1.1)	0.6 (0.2 to 0.9)
120 days	1.3 (1.1 to 1.4)	1.1 (0.8 to 1.3)	1.5 (1.0 to 1.9)	1.1 (0.3 to 1.9)	1.4 (1.1 to 1.6)	1.1 (0.7 to 1.5)
General complications						
Acute kidney injury						
30 days	2.9 (2.7 to 3.1)	2.1 (1.7 to 2.5)	1.9 (1.4 to 2.4)	1.2 (0.4 to 2.1)	3.4 (3.1 to 3.7)	1 (0.6 to 1.4)
120 days	3.4 (3.1 to 3.6)	2.4 (2.0 to 2.8)	2.6 (2.0 to 3.2)	1.5 (0.6 to 2.5)	3.9 (3.6 to 4.3)	1 (0.6 to 1.5)
Blood transfusion						
30 days	6.3 (6.0 to 6.6)	7.1 (6.5 to 7.8)	10.8 (9.7 to 11.9)	1.7 (0.7 to 2.7)	5.6 (5.2 to 6.0)	2.7 (2.0 to 3.4)
120 days	7 (6.7 to 7.3)	7.8 (7.1 to 8.5)	12.1 (11.0 to 13.3)	2 (0.9 to 3.1)	6.3 (5.8 to 6.7)	2.8 (2.1 to 3.5)
Lower respiratory tract infection						
30 days	6.7 (6.4 to 7.0)	5.4 (4.8 to 6.0)	5.2 (4.4 to 6.1)	1.7 (0.7 to 2.6)	7.8 (7.4 to 8.3)	2.7 (2.0 to 3.3)
120 days	9.1 (8.7 to 9.4)	7.5 (6.9 to 8.2)	7 (6.0 to 7.9)	3.7 (2.2 to 5.1)	10.6 (10.1 to 11.1)	3 (2.3 to 3.8)
Urinary tract infection						
30 days	4.6 (4.4 to 4.9)	4.7 (4.1 to 5.2)	4 (3.3 to 4.7)	1.8 (0.8 to 2.8)	5 (4.6 to 5.0)	2 (1.4 to 2.6)
120 days	7 (6.7 to 7.3)	6.8 (6.2 to 7.5)	6.5 (5.6 to 7.5)	3.8 (2.3 to 5.3)	7.4 (7.0 to 7.9)	2.3 (1.6 to 2.9)
Cerebrovascular accident						
30 days	0.4 (0.3 to 0.5)	0.2 (0.1 to 0.3)	0.2 (0.0 to 0.4)	0.2 (0.0 to 0.5)	0.5 (0.4 to 0.7)	0.1 (0.0 to 0.2)
120 days	0.7 (0.6 to 0.8)	0.5 (0.3 to 0.7)	0.5 (0.2 to 0.8)	0.5 (0.0 to 1.0)	0.8 (0.6 to 1.0)	0.1 (0.0 to 0.2)
Myocardial infarction						
30 days	0.6 (0.5 to 0.7)	0.5 (0.3 to 0.6)	0.4 (0.2 to 0.7)	0.3 (0.0 to 0.7)	0.7 (0.6 to 0.9)	0.1 (0.0 to 0.3)
120 days	0.7 (0.6 to 0.9)	0.6 (0.4 to 0.8)	0.5 (0.2 to 0.8)	0.5 (0.0 to 1.0)	0.9 (0.8 to 1.1)	0.1 (0.0 to 0.3)
Venous thromboembolism						
30 days	1.2 (1.1 to 1.3)	1.3 (1.0 to 1.5)	1.5 (1.0 to 1.9)	0.3 (0.0 to 0.7)	1 (0.8 to 1.2)	1.7 (1.1 to 2.2)
120 days	1.8 (1.6 to 2.0)	1.8 (1.4 to 2.1)	2.2 (1.6 to 2.7)	1 (0.2 to 1.7)	1.6 (1.3 to 1.8)	2.3 (1.6 to 2.9)
Deep vein thrombosis						
30 days	0.8 (0.8 to 0.9)	1 (0.8 to 1.3)	1.1 (0.7 to 1.5)	0.3 (0.0 to 0.7)	0.6 (0.5 to 0.8)	1.3 (0.8 to 1.8)

Continued

Table II. Continued

Outcome	Risk, % (95% CI)					
	Cohort	SHS	CMN	CS	HHA	THA
120 days	1.3 (1.1 to 1.4)	1.6 (1.2 to 1.9)	1.6 (1.1 to 2.1)	1 (0.2 to 1.7)	1 (0.8 to 1.2)	1.8 (1.2 to 2.4)
Pulmonary embolism						
30 days	0.5 (0.4 to 0.6)	0.3 (0.2 to 0.5)	0.4 (0.2 to 0.7)	0 (0.0 to 0.0)	0.5 (0.4 to 0.6)	0.8 (0.4 to 1.1)
120 days	0.7 (0.6 to 0.8)	0.5 (0.3 to 0.7)	0.6 (0.3 to 0.9)	0 (0.0 to 0.0)	0.7 (0.6 to 0.9)	0.8 (0.4 to 1.2)

CMN, cephalomedullary nail; CS, cannulated screws; HHA, hip hemiarthroplasty; N/A, not applicable; SHS, sliding hip screw; THA, total hip arthroplasty.

screws. A total of 13,359 underwent arthroplasty, of which 11,283 (46.0%) were a hip hemiarthroplasty and 2,076 (8.5%) were a total hip arthroplasty. The mean age of the overall cohort was 82.9 years (SD 8.4) and 17,186 (70.1%) were female. The baseline demographics of the patients are shown in Table I.

Ethical approval was granted by the London-Camberwell St Giles Research Ethics Committee. The study was registered with the National Institute of Health Research Portfolio (UKCRN ID12351) and the ISRCTN registry (ISRCTN63982700). Written consent to participate in the study was obtained from all patients. Those who lacked the capacity to consent were still included, in consultation with their carers.

The study was embedded within the National Hip Fracture Database (NHFD), which is a hip fracture-specific registry in which routine data on patients with hip fracture in England, Wales, and Northern Ireland are collected.[15] The WHiTE dataset captured a core outcome set of patient-reported outcome measures (PROMs) in addition to the variables which are already collected in the registry. The full list of variables and outcomes collected as part of the study has been previously described.[12] Data were stored on the OpenClinica v. 3.7 data collection system (OpenClinica, USA).

The primary outcomes of interest were all-cause mortality and surgery-specific and general complications within 120 days following surgery. The complications of interest were pre-specified and are shown in Supplementary Table i.[1,12] Complications were recorded from entries made by the treating surgical team in the patient's medical records. The 120-day follow-up period was used as the risks of mortality and the pattern of recovery typically plateau after this time.[16] Primary outcome data within 30 days of surgery were also reported, given that the 30-day observation window is the most common period of follow-up which is reported in the literature.[11]

Statistical analysis. The baseline characteristics of the patients are reported as means, SDs and proportions, as appropriate. Time-to-event analyses were carried out for each complication during the 120-day period and are presented as cumulative incidence curves. Imputation of the time to event was conducted where an event was known to have occurred within the follow-up period, but the exact time of the event was missing. Either a log-normal or uniform distribution (based on visual inspection of the pattern of events) was used. The absolute risks and 95% CIs for each complication at 30 and 120 days were calculated. Analysis was performed with R v. 4.2.3 (R Foundation for Statistical Computing, Austria). Time-to-event analyses were performed using the 'survival' R package.[17] Cumulative incidence curves were generated using the ggplot2 R package.[18]

Results

The 120-day risk of mortality was 12.4% (95% CI 12.0 to 12.8). The cumulative incidence curves for mortality are shown in Supplementary Figure a. The 30- and 120-day risks of mortality associated with each type of operation are shown in Table II, and the cumulative incidence curves in Supplementary Figure b.

The 120-day risk of peri-implant or periprosthetic fracture was 0.3% (95% CI 0.3 to 0.4), of reoperation for any indication, 2.7% (95% CI 2.5 to 2.9), of revision surgery, 1.0% (95% CI 0.9 to 1.1), of reoperation for infection, 1.1% (95% CI 1.0 to 1.2), of surgical site infection (SSI), 3.4% (95% CI 3.2 to 3.6), of superficial infection, 2.7% (95% CI 2.5 to 2.9), and of deep or organ space SSI, 1.3% (95% CI 1.1 to 1.4). The risk of dislocation in patients who were treated with an arthroplasty was 1.5% (95% CI 1.3 to 1.7). The risk of failure of fixation in those who were treated with internal fixation was 1.0% (95% CI 0.8 to 1.2). The cumulative incidence curves for surgery-specific complications are shown in Supplementary Figure c. The 30- and 120-day risks of surgery-specific complications associated with each type of operation are shown in Table II, and cumulative incidence curves are shown in Supplementary Figure d.

The 120-day risk of acute kidney injury was 3.4% (95% CI 3.1 to 3.6), of the requirement for a blood transfusion, 7.0% (95% CI 6.7 to 7.3), of lower respiratory tract infection, 9.1% (95% CI 8.7 to 9.4), of urinary tract infection, 7.0% (95% CI 6.7 to 7.3), of cerebrovascular accident, 0.7% (95% CI 0.6 to 0.8), of myocardial infarction, 0.7% (95% CI 0.6 to 0.9), of venous thromboembolism, 1.8% (95% CI 1.6 to 2.0), of deep vein thrombosis, 1.3% (95% CI 1.1 to 1.4), and of pulmonary embolism, 0.7% (95% CI 0.6 to 0.8). The 30- and 120-day risks of general complications associated with each type of operation are shown in Table II, and cumulative incidence curves are shown in Supplementary Figure b.

Discussion

The risk of mortality was low in this study, reflecting the continuing trend of declining mortality after hip fracture in recent years.[10,11] This may be attributed to the implementation of pay-for-performance initiatives, which have had a considerable impact on the quality of care of these patients.[10] However, the complication rates reported in this prospective study were higher than previously reported.[11] Reoperation rates at 30 and 120 days were nearly double those from hip fracture registries, which are about 1% and 2%, respectively.[13,19,20] Similar trends were noted for other surgery-specific and general complications. It is likely that complications are under-reported in the literature

and the real-world risks are at least equal to or higher than the risks which were found in this study. While the risk of mortality has declined, the risk of serious complications remains high in these patients, with one in three being affected.

The cumulative incidence of surgery-specific and general complications continued to rise during the four months of follow-up, with a significant proportion occurring after the immediate postoperative period and discharge from hospital. This is an important finding as many of the larger observational studies of patients with a hip fracture have only reported complications occurring during the initial inpatient period.[1,3,11,21,22] We found that these patients remain at a high risk of complications after leaving hospital. This has implications for clinicians and services involved in the care of these patients both in hospital and in the community. Thus, an increased awareness of surgery-specific complications by those responsible for the services in the community will enable early recognition and referral through the appropriate pathways, ensuring prompt treatment. There is also opportunity to explore the use of community-based interventions which might mitigate the development of these complications and improve recovery.

There were several other important findings. For patients who underwent internal fixation, treatment with a cephalomedullary nail was associated with higher risks of peri-implant fracture and reoperation compared with those treated with a sliding hip screw. The use of a cephalomedullary nail led to one additional peri-implant fracture per 200 patients and one additional reoperation per 91 patients. Treatment with cannulated screws was associated with higher risks of failure of fixation and reoperation compared with treatment using a sliding hip screw, with one additional failure per 46 patients and one additional reoperation per 32 patients. In patients who underwent arthroplasty, treatment with a total hip arthroplasty was associated with higher risks of dislocation and DVT compared with those treated with a hemiarthroplasty, equivalent to one additional dislocation per 143 patients and one additional DVT per 125 patients, respectively. These findings, however, cannot be attributed solely to the choice of operation, and may be influenced by other factors such as the type of fracture.

A key strength of this study is the combined scrutiny of hospital and community records with patient-reported follow-up to capture complications in a well-defined group of patients with complete follow-up of > 90%, 120 days after surgery. We anticipate that these findings will be generalizable to the healthcare systems of developed economies, given that the patients in the WHiTE study have been shown to be representative of the wider groups of patients with a hip fracture in the UK and comparable with other groups worldwide.[1,23]

However, the study had important limitations. The diagnosis of complications made by treating clinicians was accepted in the knowledge that these may be subject to surveillance bias, which can result in over- or under-reporting. We note, also, that associations between the type of operation and complications in this observational study do not presuppose a causal relationship and may be explained by confounding factors. In particular, confounding by the indication for surgery is likely as some operations such as a total hip arthroplasty may be reserved for fitter patients.

In summary, although the risk of mortality after hip fracture has declined in recent years, the risk of serious complications remains. We estimated that one in three patients developed a complication after surgery for their fracture. The risk of the development of these complications is associated with the choice of operation, which emphasizes the need for clinical equipoise and should be the focus for future trials.

Take home message

- In the WHiTE study, the 120-day risks of mortality and surgery-specific and general complications after hip fracture were 12.4%, 7.0%, and 30.7%, respectively.
- The risk of mortality has declined but the risk of serious complications remains high, with one in three patients affected.
- Complications may be associated with the choice of operation, emphasizing the need for clinical equipoise.

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Supplementary material

List of prespecified complications of interest and cumulative incidence curves for mortality and surgery-specific and general complications at 120 days.

References

1. **Goh EL**, **Lerner RG**, **Achten J**, **Parsons N**, **Griffin XL**, **Costa PML**. Complications following hip fracture: results from the World Hip Trauma Evaluation cohort study. *Injury*. 2020;51(6):1331–1336.
2. **Walter N**, **Szymski D**, **Kurtz SM**, **et al**. Complications and associated risk factors after surgical management of proximal femoral fractures. *Bone Jt Open*. 2023;4(10):801–807.
3. **Roche JJW**, **Wenn RT**, **Sahota O**, **Moran CG**. Effect of comorbidities and postoperative complications on mortality after hip fracture in elderly people: prospective observational cohort study. *BMJ*. 2005;331(7529):1374.
4. **Ogawa T**, **Onuma R**, **Kristensen MT**, **et al**. Association between additional weekend rehabilitation and in-hospital mortality in patients with hip fractures. *Bone Joint J*. 2023;105-B(8):872–879.
5. **Leal J**, **Gray AM**, **Prieto-Alhambra D**, **et al**. Impact of hip fracture on hospital care costs: a population-based study. *Osteoporos Int*. 2016;27(2):549–558.
6. **Cuesta-Peredo D**, **Arteaga-Moreno F**, **Belenguer-Varea Á**, **et al**. Influence of hospital adverse events and previous diagnoses on hospital care cost of patients with hip fracture. *Arch Osteoporos*. 2019;14(1):1–9.
7. **Zeelenberg ML**, **Den Hartog D**, **Panneman MJM**, **Polinder S**, **Verhofstad MHJ**, **Van Lieshout EMM**. Trends in incidence, health care consumption, and costs for proximal femoral fractures in the Netherlands between 2000 and 2019: a nationwide study. *Osteoporos Int*. 2023;34(8):1389–1399.
8. **Socci AR**, **Casemyr NE**, **Leslie MP**, **Baumgaertner MR**. Implant options for the treatment of intertrochanteric fractures of the hip rationale, evidence, and recommendations. *Bone Joint J Brit Ed Soc Bone Joint Surg*. 2017;99-B(1):128–133.
9. **Perry DC**, **Metcalfe D**, **Griffin XL**, **Costa ML**. Inequalities in use of total hip arthroplasty for hip fracture: population based study. *BMJ*. 2016;353:i2021.
10. **Metcalfe D**, **Zogg CK**, **Judge A**, **et al**. Pay for performance and hip fracture outcomes: an interrupted time series and difference-in-differences analysis in England and Scotland. *Bone Joint J*. 2019;101-B(8):1015–1023.
11. **Goh EL**, **Khatri A**, **Costa AB**, **et al**. Prevalence of complications in older adults after surgery for a hip fracture: a systematic review and meta-analysis. *Bone Joint J*. 2025;107-B(2):139–148.
12. **Costa ML**, **Griffin XL**, **Achten J**, **et al**. World Hip Trauma Evaluation (WHiTE): framework for embedded comprehensive cohort studies. *BMJ Open*. 2016;6(10):e011679.

13. **No authors listed**. The 2023 National Hip Fracture Database Report on 2022. National Hip Fracture Database. 2023. https://www.nhfd.co.uk/reportopen/NHFD-2023+Annual+Report (date last accessed 3 February 2024).
14. **No authors listed**. Hip fracture: management. Clinical guideline [CG124]. National Institute for Health and Care Excellence. 2023. https://www.nice.org.uk/guidance/cg124 (date last accessed 3 February 2024).
15. **Johansen A**, **Hall AJ**, **Ojeda-Thies C**, **Poacher AT**, **Costa ML**, **Global Fragility Fracture Network Hip Fracture Audit Special Interest Group**. Standardization of global hip fracture audit could facilitate learning, improve quality, and guide evidence-based practice. *Bone Joint J*. 2023;105-B(9):1013–1019.
16. **Griffin XL**, **Parsons N**, **Achten J**, **Fernandez M**, **Costa ML**. Recovery of health-related quality of life in a United Kingdom hip fracture population. The Warwick Hip Trauma Evaluation--a prospective cohort study. *Bone Joint J*. 2015;97-B(3):372–382.
17. **Therneau TM**. A package for survival analysis in R. CRAN. 2023. https://cran.r-project.org/web/packages/survival/vignettes/survival.pdf (date last accessed 3 February 2025).
18. **Wickham H**. *Ggplot2: Elegant Graphics for Data Analysis*. New York, New York: Springer-Verlag, 2016.
19. **Ellanti P**, **Cushen B**, **Galbraith A**, **Brent L**, **Hurson C**, **Ahern E**. Improving hip fracture care in Ireland: a preliminary report of the Irish Hip Fracture Database. *J Osteoporos*. 2014;2014:656357.
20. **No authors listed**. Annual Report 2023. Australian & New Zealand Hip Fracture Registry. 2023. https://anzhfr.org/wp-content/uploads/sites/1164/2023/09/ANZHFR-2023-Annual-Report-%E2%80%93-eReport-%E2%80%93-FINAL.pdf (date last accessed 3 February 2025).
21. **Prieto-Alhambra D**, **Reyes C**, **Sainz MS**, **et al**. In-hospital care, complications, and 4-month mortality following a hip or proximal femur fracture: the Spanish registry of osteoporotic femur fractures prospective cohort study. *Arch Osteoporos*. 2018;13(1):96.
22. **Lawrence VA**, **Hilsenbeck SG**, **Noveck H**, **Poses RM**, **Carson JL**. Medical complications and outcomes after hip fracture repair. *Arch Intern Med*. 2002;162(18):2053–2057.
23. **Metcalfe D**, **Costa ML**, **Parsons NR**, **et al**. Validation of a prospective cohort study of older adults with hip fractures. *Bone Joint J*. 2019;101-B(6):708–714.

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Data sharing:
The datasets generated and analyzed in the current study are not publicly available due to data protection regulations. Access to data is limited to the researchers who have obtained permission for data processing. Further inquiries can be made to the corresponding author.

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