Reoperation-free survival after hip screws or hip arthroplasty for undisplaced femoral neck fractures in the elderly

a nationwide population-based cohort study of 3,909 patients

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Aims

Our primary aim was to assess reoperation-free survival at one year after the index injury in patients aged ≥ 75 years treated with internal fixation (IF) or arthroplasty for undisplaced femoral neck fractures (uFNFs). Secondary outcomes were reoperations and mortality analyzed separately.

Methods

We retrieved data on all patients aged ≥ 75 years with an uFNF registered in the Swedish Fracture Register from 2011 to 2018. The database was linked to the Swedish Arthroplasty Register and the National Patient Register to obtain information on comorbidity, mortality, and reoperations. Our primary outcome, reoperation, or death at one year was analyzed using restricted mean survival time, which gives the mean time to either event for each group separately.

Results

Overall, 3,909 patients presenting with uFNFs were included. Of these patients, 3,604 were treated with IF and 305 with primary arthroplasty. There were no relevant differences in age, sex, or comorbidities between groups. In the IF group 58% received cannulated screws and 39% hook pins. In the arthroplasty group 81% were treated with hemiarthroplasty and 19% with total hip arthroplasty. At one year, 32% were dead or had been reoperated in both groups. The reoperation-free survival time over one year of follow-up was 288 days (95% confidence interval (CI) 284 to 292) in the IF group and 279 days (95% CI 264 to 295) in the arthroplasty group, with p = 0.305 for the difference. Mortality was 26% in the IF group and 31% in the arthroplasty group at one year. Reoperation rates were 7.1% in the IF group and 2.3% in the arthroplasty group.

Conclusion

In older patients with a uFNF, reoperation-free survival at one year seems similar, regardless of whether IF or arthroplasty is the primary surgery. However, this comparison depends on the choice of follow-up time in that reoperations were more common after IF. In contrast, we

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found more early deaths after arthroplasty. Our study calls for a randomized trial comparing these two methods.

Take home message

- Primary arthroplasty is an option for undisplaced femoral neck fractures in older adults.
- Reoperation-free survival did not differ between patients treated with internal fixation or arthroplasty for up to one year when considering mortality and reoperation outcomes.

Introduction

The routine surgical procedure for undisplaced femoral neck fractures (uFNFs) in Sweden, regardless of the patient's age, is internal fixation (IF) with two to three screws or hook pins.[1] In older patients, reoperation rates ranging between 8% and 27% after IF of uFNFs have been reported.[2-5] Advanced age has been described as a risk factor for healing complications in uFNFs treated with IF, but less for primary arthroplasty.[2,6] One in ten patients aged > 60 years with an uFNF receiving IF will be converted to arthroplasty within five years, and females and patients aged 70 to 79 years have an increased risk of conversions.[7] In older patients with displaced FNFs treated with primary hemiarthroplasty, the reoperation rate is lower than after undisplaced fractures treated with IF.[3,8,9] Primary arthroplasty for uFNFs has therefore been advocated.

A randomized controlled trial (RCT) comparing modern hemiarthroplasty with screw fixation for uFNFs on 219 patients found no significant difference in hip function, but hemiarthroplasty conferred improved mobility and fewer major reoperations.[8] Larger national RCTs are currently enrolling patients in the UK (Fruiti Trial),[10] Denmark (Sense Trial),[11] and Sweden (Hipsther Trial),[12] with varying lower age limits (aged ≥ 60, ≥ 65, and ≥ 75 years). Results from these trials are not expected until 2025 at the earliest.

Our main goal was therefore to evaluate reoperation-free survival of patients treated with IF compared to arthroplasty one year after the index injury in an explorative study. Secondary aims were to compare mortality and reoperation rates separately between groups. We performed a nationwide population-based cohort study linking data from the Swedish Fracture Register (SFR), the Swedish Arthroplasty Register (SAR), and the National Patient Register (NPR).

Methods

Data sources

Data for eligible patients were retrieved from the SFR. In the SFR, all fracture types in adults are registered since 2011 and all long-bone fractures in children since 2015.[13,14] The SFR is a unique national quality register as it contains information on fractures, regardless of treatment (surgical or non-surgical). Coverage increased from the start in one department in 2011 to > 80% of all Swedish departments at the end of the present study in 2018.

The SFR collects details on injury mechanism, sex, age, treatment type (hemi- or total arthroplasty, or IF, including cannulated screws, hook pins, or sliding hip screws), and mortality.

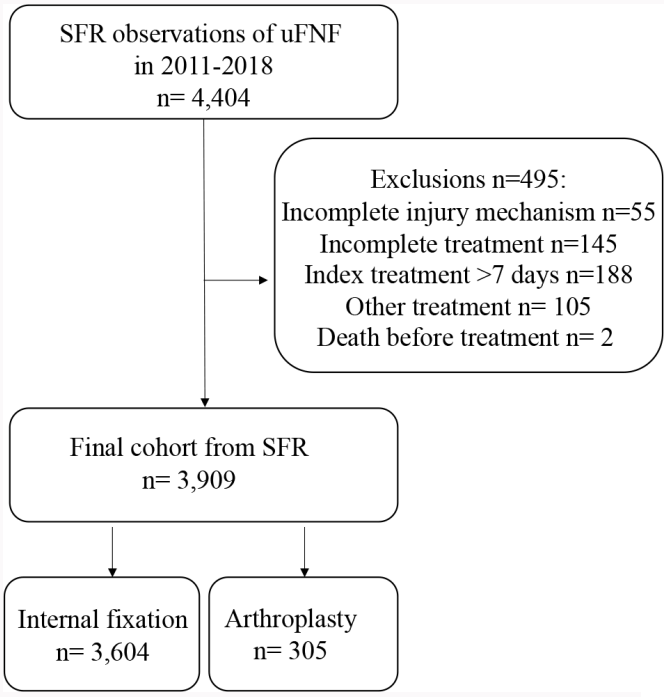

Fig. 1
Flowchart of study patients.

Using the personal identity number (PIN) given to all Swedish permanent residents, patients identified in the SFR were linked with the SAR to obtain data on reoperations after arthroplasty or conversion to arthroplasty after failed IF. In addition, the cohort was linked to the NPR to obtain data on subsequent reoperations and preoperative comorbidities. The NPR does not include data on laterality. ICD codes registered up to one year before the index date were used to calculate the Charlson Comorbidity Index (CCI), using an adaptation for registered-based research in Sweden.[15]

The reporting of this observational register study follows the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Patient selection

We retrieved data on all patients aged ≥ 75 years at injury with a registered uFNF (Garden I-II, AO-OTA 31-B1) between 2011 and 2018. Exclusion criteria were stress-induced, spontaneous, pathological, and peri-implant fractures. Subsequent contralateral uFNFs were also excluded to avoid dependency issues for mortality and laterality problems in case of reoperations. From the retrieved cohort, we excluded patients with incomplete registrations for injury mechanism or treatment, index treatment > seven days from injury, or erroneous entries (death date before registered treatment date) (Figure 1). Finally, treatments other than arthroplasty and IF were also excluded.

Outcome measures

All reoperations registered in the SFR, SAR, and NPR were retrieved. Reoperations were registered in one or a combination of the registers. Primary analyses used data

from the SFR and SAR. Sensitivity analyses using data from the NPR without laterality codes were used to illustrate the worst-case scenario where we did not completely control the side of reoperation. Reoperation was grouped into primary arthroplasty after failure of IF, extraction of IF, reoperation due to infection, revision arthroplasty, or excision arthroplasty (Girdlestone) using the procedural codes from the registries (see Supplementary table i).

The primary outcome was a composite variable of death or reoperation within one year. The time from the index surgery to death or reoperation, whichever occurred first, was considered the time-to-event. Secondary outcomes were mortality and reoperation rates.

Statistical analysis

Baseline variables were presented as frequencies and percentages of non-missing values for categorical variables and medians with interquartile ranges (IQRs) for continuous variables. Treatment groups were compared using the Wilcoxon rank-sum test or chi-squared test. Crude event rates were summarized in tables with the number and percentage of patients with events. Cumulative event rates for the outcomes were visualized using Kaplan-Meier plots. Time to outcome/censoring was calculated using calendar days with date of the index treatment as day zero. For all outcomes, censoring was one year after the index injury. For the outcome of reoperation, death was treated as a censoring event. The predefined analysis plan used Cox regression models. However, there was evidence of violating the proportional hazards assumption for the outcomes at one year. The smooth estimate of the time-dependence of the hazard ratio (HR) for IF versus arthroplasty was plotted. Hence, we used the restricted mean survival time (RMST) analysis to assess the time to either reoperation or death for up to one year as the primary analysis. This analysis gives the mean time to either event for each group separately. Both Kaplan-Meier-based unadjusted RMST and RMST using regression models were calculated. In the later we included age, sex, and CCI in the models using the survRM2 package in R. Differences in RMST with 95% confidence intervals (CI) and p-values were presented. All statistical tests were two-sided. A p-value < 0.05 was considered statistically significant.

The software packages R 4.1.2 (R Foundation for Statistical Computing, Austria) and SAS 9.4 (SAS Institute, USA) were used for data management and statistical analyses.

Ethics and conflict of interest

The study was approved by the Swedish Ethical Review Authority (dnr 2020-02716) and conducted in accordance with the ethical principles of the Declaration of Helsinki. We are favourable to sharing data but are legally restricted from doing so according to the law on Public Access and Secrecy (chapter 21, paragraph 7, and chapter 25, paragraph 1).[16] An application for data extraction can be sent to the Centre of Registers, Västra Götaland, after an approved ethical application.

Results

Overall, 3,909 patients with uFNFs were included. Of these 3,909 patients, 305 (7.8%) were treated with arthroplasty, while the others received IF. The distributions of age, sex, and comorbidities were similar in both treatment groups (Table I). Most patients in the IF group had hook pins or cannulated screws inserted.

Cemented hemiarthroplasty was the most common treatment in the arthroplasty group. There was large variation in the choice of treatment methods among the 41 departments contributing to the study cohort, ranging from 0% to 28% of patients being treated with arthroplasty.

Table I. Baseline demographics of 3,909 patients with an undisplaced femoral neck fracture treated with internal fixation or arthroplasty.

Variable	Internal fixation (n = 3,604)	Arthroplasty (n = 305)	p-value
Median age, yrs (IQR)	85 (80 to 89)	85 (82 to 89)	0.101*
Male sex, n (%)	1,148 (32)	112 (37)	0.092†
Median CCI (IQR)	0 (0 to 1)	0 (0 to 1)	0.954*
Treatment, n (%)			
Hook pins	2,089 (58)	N/A	
Cannulated screws	1,418 (39)	N/A	
Sliding hip screw	97 (2.7)	N/A	
Hemiarthroplasty	N/A	246 (81)	
Total hip arthroplasty	N/A	59 (19)	

*Wilcoxon rank-sum test.
†Pearson's chi-squared test.
CCI, Charlson Comorbidity Index; IQR, interquartile range; N/A, not applicable.

Table II. Differences in restricted mean survival time, including reoperation-free survival (composite variable) at one year and 180 and 90 days after index treatment for 3,909 undisplaced femoral neck fractures treated with internal fixation (n = 3,604) or arthroplasty (n = 305).

	Unadjusted		Adjusted	
RMST difference	Estimate (95% CI)	p-value*	Estimate (95% CI)	p-value*
1 year	8.43 (-7.7 to 24.6)	0.305	6.69 (-9.0 to 22.3)	0.402
180 days	7.67 (0.5 to 14.8)	0.036	6.46 (-0.3 to 13.3)	0.063
90 days	4.37 (1.3 to 7.5)	0.006	3.89 (0.9 to 6.9)	0.011

Unadjusted and adjusted for age, sex, and Charlson Comorbidity Index.
*Wald chi-squared test for the effect of treatment, from survRM2 package in R.
CI, confidence interval; RMST, restricted mean survival time.

Primary outcome: reoperation or death

The reoperation free survival time over 365 days of follow-up was 288 days (95% CI 284 to 292) in the IF group and 279 days (95% CI 264 to 295) in the arthroplasty group, with p = 0.305 for the difference. After adjustment for confounders, the difference between groups was 6.7 days (95% CI -9 to 22.3) at one year (p = 0.402) (Table II). One year after index surgery, 32% of the patients had died or had been reoperated in the IF

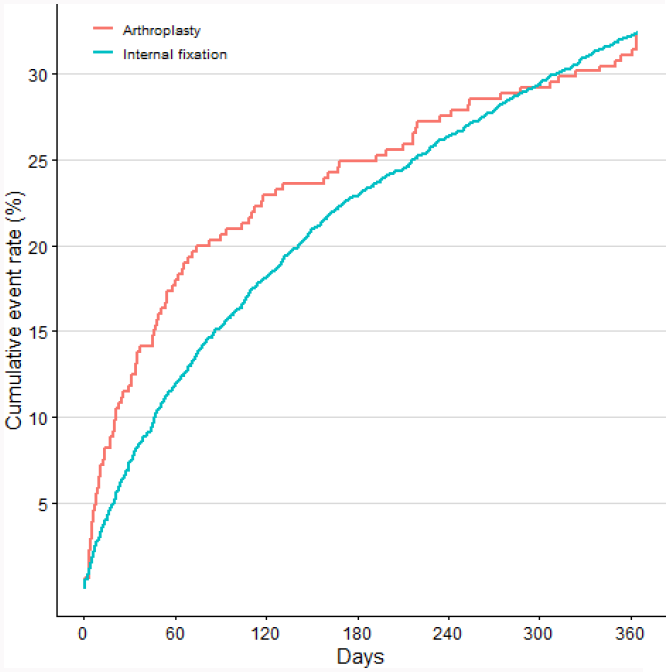

Fig. 2
Kaplan-Meier estimated cumulative events for reoperation/death at one year for the internal fixation and arthroplasty groups.

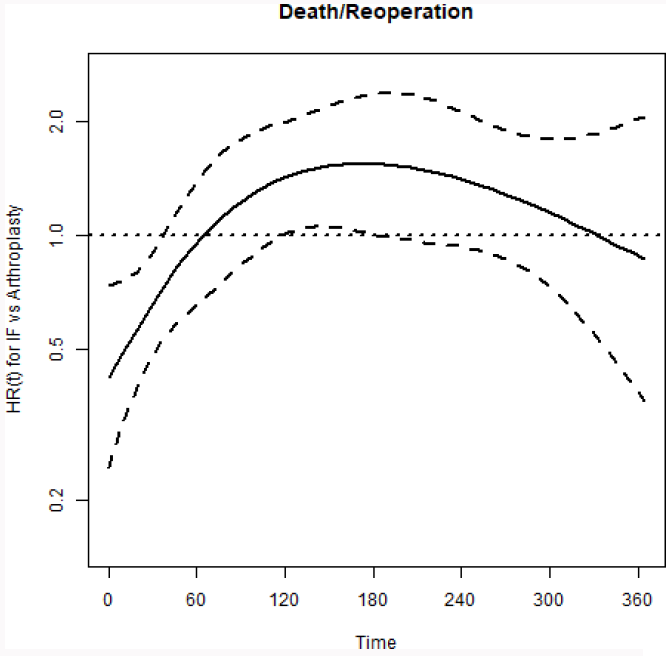

Fig. 3
Estimate of the ratio of hazard function for death/reoperation over time (days) for the internal fixation versus arthroplasty.

(1,168 of 3,604) and arthroplasty groups (98 of 305). Cumulative event rates for the composite outcome (reoperation or death) are shown in Figure 2. The hazard ratio (HR) for the composite variable changed over time, with a lower HR during the first two months for IF and a higher HR from ≥ two months (Figure 3).

Secondary outcome: mortality alone

Crude mortality rates were higher early after treatment for the arthroplasty group, with remaining differences at one year (Table III). In all, 30-day and one-year crude mortality rates were 6.5% (n = 235) and 26.3% (n = 947), respectively, for IF compared to 11.1% (n = 34) and 30.8% (n = 94) for arthroplasty, respectively. Cumulative event rates for mortality for IF and arthroplasty are shown in Figure 4.

Secondary outcome: reoperation alone

At one year, the crude reoperation rate was 7.1% (n = 255) in IF and 2.3% (n = 7) in arthroplasty (Table III). Conversion to total hip arthroplasty was the most common procedure in the IF group. Reoperations in the arthroplasty group were revision arthroplasty or reoperation due to infection. Cumulative reoperation rates for IF and arthroplasty are displayed in Figure 5.

Table III. Crude rates of the composite variable (death or reoperation) and mortality and reoperation rates for 3,909 undisplaced femoral neck fractures treated with internal fixation.

Variable	Internal fixation (n = 3,604), n (%)	Arthroplasty (n = 305), n (%)
Death/reoperation at 1 year	1,168 (32)	98 (32)
Mortality at 7 days	85 (2.4)	15 (4.9)
Mortality at 30 days	234 (6.5)	34 (11)
Mortality at 90 days	460 (13)	58 (19)
Mortality at 1 year	947 (26)	94 (31)
Reoperation at 1 year	255 (7.1)	7 (2.3)
Reoperation types		
Conversion to THA	228 (6.3)	0 (0.0)
Revision arthroplasty	0 (0.0)	4 (1.3)
Extraction of IF	17 (0.5)	0 (0.0)
Excision arthroplasty	4 (0.1)	0 (0.0)
Reoperation due to infection	6 (0.2)	3 (1.0)

Data from the Swedish Fracture Register and the Swedish Arthroplasty Register.
IF, Internal fixation; THA, total hip arthroplasty.

Sensitivity analysis

Because of missing laterality codes in the NPR, we used these data only for a sensitivity analysis displaying the worst-case scenario.

When adding data from the NPR, 36% (n = 1,309) of patients in the IF group had experienced a composite outcome at one year compared to 33% (n = 102) in the arthroplasty group. The crude reoperation rate when adding procedures from the NPR was 12% (n = 439) in the IF group and 3.9% (n = 12) in the arthroplasty group.

Discussion

Reoperation-free survival did not differ between IF or arthroplasty in uFNF patients aged ≥ 75 years one year after the index procedure. Patients in the IF group had a substantially higher total reoperation rate, with the most

pronounced increase in event rate during the first six months. In contrast, patients in the arthroplasty group had a higher early mortality rate, with the most pronounced increase in event rate within 30 days after the index procedure, but no statistically significant difference in mortality after one year. These reoperation and mortality rates translated into a statistically non-significant difference for reoperation-free survival between groups.

The primary outcome variable (death or reoperation) was selected because of the difference in magnitude of the two treatment procedures. IF with screws or hook pins is a short and minimally invasive procedure performed percutaneously compared to the more invasive hip arthroplasty procedure with the risk of perioperative blood loss and bone cement implantation syndrome. The arthroplasty procedure is believed to confer higher perioperative stress to the patient, and may increase early mortality in these patients. However, this notion is disputed as a recent RCT from Norway in 219 patients found that patients in an IF group had increased mortality rates up to 24 months over those allocated to hemiarthroplasty.[8] For primary arthroplasty, we speculate that modern anesthesia and third-generation cementing techniques could help minimize perioperative risks.[17] Moreover, a more predictable return to pre-injury function with hip arthroplasty compared to the prolonged, sometimes painful healing process with IF might be desirable in some patients. Improved mobility can benefit the patient with increased autonomy and less risk of bedsores, infection, and thromboembolic events. The major differences in mortality in this study are likely explained by a selection bias in which patients treated with arthroplasty may have fractures with increased dorsal tilt (frailer bone), implying increased frailty. The mortality rates in our study after an uFNF were somewhat higher than in the RCT by Dolatowski et al,[8] who reported one-year mortality rates of 23% in the IF group and 18% in the hemiarthroplasty group. The differences could be explained by the selection of younger patients (aged ≥ 70 years), and that all eligible patients were included in our observational register study compared to the selection of healthier patients giving informed consent for participation in the RCT.[18] In retrospective cohort studies of patients with only IF for uFNFs reported one-year mortality rates were 19% to 22%.[4,19,20] These studies included younger patients: two included patients ≥ aged 60 years;[4,20] and one included all patients in the department's database (35 to 106 years).[19]

Reoperation rates from 8% to 27% after an uFNF have been reported in patients with IF in single-centre studies.[2-5] The reoperation rates in our study, when using data from the SFR and SAR, are in the lower range. Even when adding data lacking laterality codes from the NPR, our reoperation rates were still in the lower range after one year compared to previously reported rates. In a previous publication on 1,505 uFNFs treated with IF, only 64% of patients with a treatment failure underwent a reoperation within two years postoperatively.[20] Our study's short follow-up time of one year could partly explain the low reoperation rates after IF. Also, including patients aged ≥ 75 years increases the risk for a proportion of patients unfit to seek healthcare services actively, and may therefore mask the true complication and reoperation rate. The SFR and SAR data include all major reoperations and conversions to arthroplasty, whereas adding the NPR data adds data mainly on minor reoperations such as implant removal.

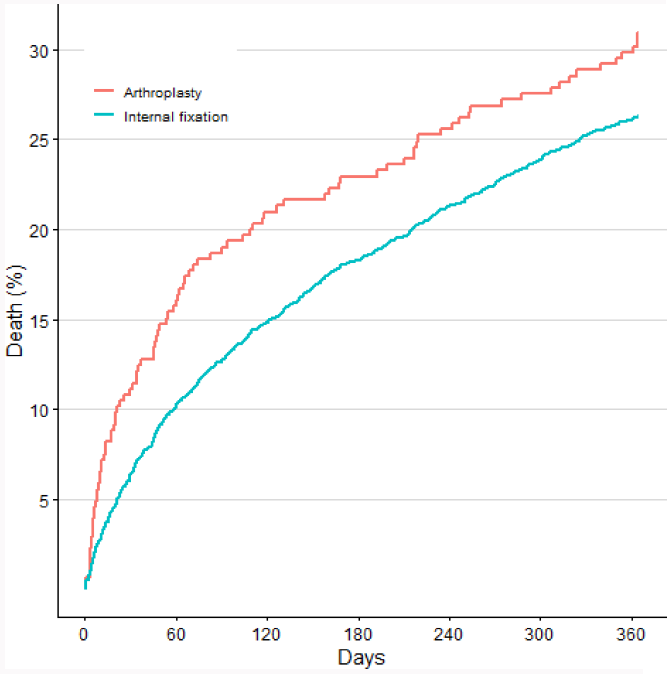

Fig. 4
Kaplan-Meier estimated cumulative events for mortality at one year for the internal fixation and arthroplasty groups.

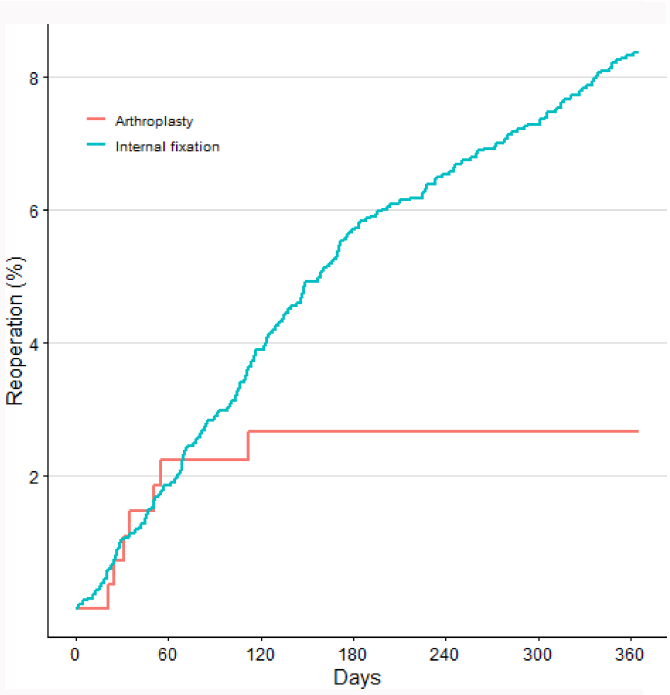

Fig. 5
Kaplan-Meier estimated cumulative events for reoperation at one year for the internal fixation and arthroplasty groups.

The inter-departmental variation of arthroplasty for an uFNF from 0% to 28% can partly be explained by the increased attention to the degree of dorsal and anterior tilt on the lateral radiograph. This variation is likely to affect treatment given differently in the contributing departments without national guidelines. Other factors that could not be assessed are pre-injury arthritis, time between fracture and treatment, and infection and bedsores. By adopting treatment with hip arthroplasty for the approximately 25% of patients presenting with an uFNF that have an anterior tilt over 10° or a dorsal tilt above 20°, we could reduce the need for secondary surgery for the entire population of uFNFs. However, which subgroups of patients with uFNFs benefit from a hip arthroplasty remains to be determined in future RCTs.[11,12]

Strengths and limitations

Using a national fracture register allowed us to include all registered patients with uFNFs, regardless of treatment, and to compare IF and arthroplasty based on co-processing national registers and the unique PIN. The accuracy of femur fracture classification in the SFR has been reported to be substantial to perfect when comparing the registered classification to an expert group.[21] The observational design of the study enabled us to include all eligible patients, yielding a high external validity of our results as opposed to an RCT, which generally has high internal validity but could differ from the general practice because it excludes certain subgroups of patients (e.g. cognitive dysfunction, alcohol and substance abuse, and severe comorbidities). The missing laterality code in the NPR forced us to use these data as a sensitivity analysis only, with a worst-case outcome for reoperations. The procedures found in this extended dataset may have been performed on the contralateral hip, resulting in the risk of false-positive effects. Ideally, these procedures could have been verified by reviewing medical records, but with over 40 contributing departments, this was not feasible in the current setting. Another limitation is the short follow-up, resulting in a lower reoperation rate for those receiving IF. Since this is an observational study on registry data with a one-year follow-up, an unknown number of patients may be on waiting lists for reoperation. A number of potential future reoperations may therefore not be accounted for which leads to an underestimation of the true number of reoperations. We lack information on the indication for revision arthroplasty in the arthroplasty group but dislocation may be a probable cause.

In conclusion, in this observational register study of patients aged ≥ 75 years with uFNFs we found no difference in reoperation-free survival one year after IF or arthroplasty. The different procedures in this study have varying risks for death and reoperation. Hip arthroplasty confers a slightly higher risk of death, whereas IF has a considerably increased risk of reoperation. These risks must be considered when deciding on treatment for the individual patient with an uFNF. Our findings require adequately powered randomized trials comparing the two alternative treatment approaches.

Supplementary material

Table showing reoperation groups based on procedural codes from the Swedish Fracture Register, the Swedish Arthroplasty Register, and the National Patient Register.

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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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Ethical review statement

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