Intramedullary nail versus sliding hip screw for stable and unstable trochanteric and subtrochanteric fractures in 17 341 patients from the Norwegian Hip Fracture Register

Kirsten Marie Larsen Grønhaug, MD, Orthopaedic Surgeon [1,2]

Eva Dybvik, MSc, PhD, Senior Statistician [3]

Kjell Matre, MD, PhD, Orthopaedic Surgeon [2,3]

Bengt Östman, MD, PhD, Orthopaedic Surgeon [1]

Jan-Erik Gjertsen, MD, PhD, Orthopaedic Surgeon [2,3]

[1] Department of Orthopaedic Surgery, Østfold Hospital Trust, Kalnesveien 300, 1714 Grålum, Norway

[2] Department of Clinical Medicine, University of Bergen, Jonas Lies veg 87, 5021 Bergen, Norway

[3] Norwegian Hip Fracture Register, Department of Orthopaedic Surgery, Haukeland University Hospital, Møllendalsbakken 7, 5021 Bergen, Norway

Correspondence: kirstengroenhaug@gmail.com

Author contributions:

K. M. L. Grønhaug: Planned and designed the study. Statistical analysis, Interpreted the results, Drafted and revised the manuscript.

E. Dybvik: Statistical analysis, Interpreted the results, Revised the manuscript.

K. Matre: Planned and designed the study, Interpreted the results, Revised the manuscript.

B Östman: Planned and designed the study, Statistical analysis, Interpreted the results, Revised the manuscript.

J-E. Gjertsen: Planned and designed the study, Statistical analysis, Interpreted the results, Revised the manuscript.

Abstract

Aims

To investigate if there are differences in outcome between sliding hip screw (SHS) and intramedullary nail (IMN) with regard to fracture stability.

Patients and Methods

We assessed data from 17 341 patients with trochanteric or subtrochanteric fractures treated with SHS or IMN in the Norwegian Hip Fracture Register from 2013 to 2019. Primary outcome measures were reoperations for stable fractures (AO/OTA type A1) and unstable fractures (AO/OTA type A2, A3 and subtrochanteric fractures). Secondary outcome measures were reoperations for A2, A3 and subtrochanteric fractures individually, one-year mortality, quality of life (EQ-5D-3L), pain (Visual Analogue Scale (VAS)), and satisfaction (VAS) for stable and unstable fractures. Hazard rate ratios (HRRs) for reoperation were calculated using Cox regression analysis with adjustments for age, sex and ASA-score.

Results

Reoperation rate was lower after surgery with IMN for unstable fractures one year (HRR: 0.82, 95% CI: 0.70 to 0.97, p=0.02) and three years postoperatively (HRR: 0.86, 95% CI: 0.74 to 0.99, p=0.036), compared to SHS. For individual fracture types, no clinically significant differences were found. Lower 1-year mortality was found for IMN compared to SHS for stable (HRR: 0.87, 95% CI: 0.78 to 0.96, p=0.007), and unstable fractures (HRR: 0.91, 95% CI: 0.84-0.98, p=0.014).

Conclusion

This national register-based study indicates a lower reoperation rate for IMN than SHS for unstable trochanteric and subtrochanteric fractures, but not for stable fractures or individual fracture types. The choice of implant may not be decisive to the outcome of treatment for

stable trochanteric fractures in terms of reoperation rate. One-year mortality rate for unstable and stable fractures was lower in patients treated with IMN.

Bullet points

- Lower reoperation rate for unstable fractures treated with IMN compared to SHS

- Comparable outcomes in SHS and IMN in stable fractures and individual fracture types

- Lower 1-year mortality rates in patients treated with IMN

- In the treatment of unstable fractures, the use of SHS was more likely to lead to infection and complications that required THA

- In the treatment of stable fractures, IMN was associated with increased prevalence of peri-implant fracture as a cause for reoperation

Introduction

The choice of implant in the treatment of trochanteric fractures and subtrochanteric fractures has been debated for decades without reaching consensus.[1, 2]

The most common implants are extramedullary sliding hip screws (SHS) and intramedullary nails (IMN),[2] skewing towards IMN over the past two decades.[3] The IMN has historically had a higher risk of peri-implant fractures.[2] However, modern nail designs may have reduced this difference.[2, 4] Accordingly, results from earlier studies comparing the two treatment methods may no longer be valid in the context of revised treatment recommendations.[4] Results from the available literature are conflicting. Recent studies have been unable to demonstrate any significant differences in outcome[5, 6], whereas others report a beneficial effect of IMNs in the treatment of unstable trochanteric and subtrochanteric fractures.[7, 8] A long IMN is now recommended as the implant of choice for AO/OTA A3 trochanteric fractures and subtrochanteric fractures in several countries,[9] although the superiority of the IMN is still debatable. An association between increased 30-day mortality and intramedullary nails in the treatment of trochanteric fractures has been proposed,[10] and there are still reports on higher risk of peri-implant fracture with IMN than SHS.[11] In this study, based on data from the Norwegian Hip Fracture Register (NHFR) from 2013-2019, we compared reoperation rates between SHS and IMN in stable fractures (AO/OTA A1) and unstable fractures (AO/OTA A2, AO/OTA A3 and subtrochanteric combined) one and three years postoperatively. Secondary aims were to compare reoperation rates between SHS and IMN in A2, A3 and subtrochanteric fractures separately, and to compare mortality and patient-reported outcomes after SHS and IMN for stable and unstable fractures one year after surgery.

Materials and Methods

This prospective cohort study is based on data from a national registry, the NHFR. The reporting rate was 88% for primary osteosynthesis and 80% for reoperations in 2018.[12] The surgeon reports information on the patient, the fracture, and the operation in a one-page form. PROMs (patient-reported outcome measures) questionnaires are sent to all patients four, twelve and thirty-six months postoperatively, where the four-month questionnaire also includes questions on preoperative status. Preoperative status and data from the twelve-month questionnaire were included in the present study. Trochanteric fractures were classified according to the AO/OTA classification system as AO/OTA type A1 (simple two-part), A2 (multifragmentary), and A3 (intertrochanteric/reverse oblique).[13] Subtrochanteric fractures were defined as diaphyseal fractures with the centre of the fracture less than five cm distal to the lesser trochanter.[13] Further, we defined all A1 fractures as stable and A2, A3 and subtrochanteric fractures as unstable.[14]

We included patients with trochanteric or subtrochanteric fractures treated with an SHS with or without a trochanteric support plate (TSP) or a short or long IMN, treated from January 2013 to December 2018. Patients aged < 60 years, patients treated with other implants than SHS or IMN, patients with pathological fractures (other than osteoporosis), and patients with missing data (ASA classification, fracture type, type of implant) were excluded. Finally, 17 341 patients were included in the reoperation analysis. Of these, 9 830 (56.7%) were treated with an SHS and 7 511 (43.3%) with an IMN (Figure 1). Reoperations were categorized according to indication and type. Cause of reoperation was not readily available in patients receiving THA as these operations are recorded in the Norwegian Arthroplasty Register (NAR), using a different form. Consequently, cause of reoperation recorded in the NAR was labelled “unspecified sequelae (THA)”. More than one cause may be given for each reoperation in the NHFR. The following hierarchy was chosen to identify the most severe cause in each case: infection, peri-implant fracture, mechanical complications (non-union, implant failure, cut-out), unspecified sequelae (treated with THA), pain alone, other. Risk of reoperation at one and three years was calculated. One-year mortality was calculated and compared for patients treated with SHS and IMN. Patient reported outcome was compared one year postoperatively using the EQ-5D index score (EQ-5D-3L, EuroQol Group, Rotterdam, The Netherlands) a visual analogue scale (VAS) 0-100 for pain (0 = no pain, 100 = unbearable pain), and a VAS 0-100 for satisfaction (0 = least satisfied, 100 = most satisfied). Of the 17 341 patients included, 12 810 (73.9%) patients were still alive after one year. A twelve-month questionnaire was sent to 12 694 patients (73.2%). Of these, 6 632 (52.2%) responded and were included in the PROM analysis. Stable fractures (A1) and unstable fractures (A2, A3 and subtrochanteric) were analysed separately with regard to reoperation rates and PROM data. Further, subgroup analyses for each of the unstable fracture types were performed. SHS with and without a TSP were analysed as one group, as were short and long IMNs.

We chose to compare SHS and IMN in the treatment of stable fractures and unstable fractures, as A3 and subtrochanteric fractures are less common and classification errors between A2, A3 and subtrochanteric fractures are frequent.[15, 16] Erratic coding may obscure the true complication rates of implants used to treat different fracture subgroups.[14] To make the statistical analysis more robust and more clinically relevant, we considered A2, A3 and subtrochanteric as one group, acknowledging fracture instability as the common denominator.

Statistical analysis

Baseline data were analysed using the Pearson chi-square test and ANOVA for categorical variables, and the independent sample t-test for continuous variables. Hazard rate ratios (HRRs) of reoperations and hierarchical cause of reoperation were calculated using Cox regression analysis, adjusted for age, sex and ASA classification. Patients were followed from primary operation to reoperation, death, or 31 December 2019 (end of study), whichever occurred first. One-year mortality for SHS and IMN was calculated for stable and unstable fractures using Cox regression analysis adjusted for age, sex and ASA classification. The proportional hazards assumption was tested using log-minus-log plots and was fulfilled. Patient-reported quality of life (EQ-5D-3L), pain (VAS 0-100), and satisfaction (VAS 0-100) twelve months postoperatively were recorded, and we used the independent sample t-test to compare means between SHS and IMN. The significance level was set at 0.05. The statistical analysis was performed using IBM SPSS Statistics, version 26 (IBM Corp, Armonk, NY, USA) and the R statistical package (http://CRAN.R-project.org).

The STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) guidelines were followed.[17]

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Results

The study population included 9 830 patients operated with an SHS and 7 511 with an IMN. Overall, 71% of the patients with an SHS and 73% of those with an IMN were women, and the mean age was 83.2 and 82.9 years, respectively. Approximately 70% of the patients were classified as ASA 3 or 4 in both treatment groups (Table I). An SHS with TSP was chosen in 7% of A1 fractures, 50% of A2 fractures, 82% of A3 fractures, and 68% of subtrochanteric fractures treated with an SHS. A long nail was chosen in 9% of A1 fractures, 29% of A2 fractures, 65% of A3 fractures, and 88% of subtrochanteric fractures treated with an IMN.

Reoperations

Number and type of reoperation for each fracture type are listed in Table II. No difference in overall risk of reoperation was found between SHS and IMN for stable fractures one year postoperatively (HRR: 1.1, 95% CI: 0.79 to 1.51, p=0.60) or three years postoperatively (HRR 1.0, 95% CI: 0.75 to 1.32, p=0.98), but peri-implant fracture was a more frequent cause of reoperation with the use of IMN (HRRs: 5.9 and 5.8 respectively) (Table III). For unstable fractures there was a lower overall risk of reoperation for IMN than for SHS one year postoperatively (HRR: 0.82, 95% CI: 0.70 to 0.97, p=0.022) and three years postoperatively (HRR: 0.86, 95% CI: 0.74 to 0.87, p=0.009). Further, the risk of reoperation due to infection one and three years postoperatively (HRRs: 0.6 and 0.6 respectively), and the risk of reoperation with THA one and three years postoperatively (HRRs: 0.6 and 0.7 respectively), were lower for IMN than for SHS (Table IV). Implant survival curves for SHS and IMN for stable fractures and unstable fractures are shown in Figure 2. When the unstable fracture types were investigated individually, SHS was found to have a higher risk of reoperation for any cause for A3 fractures at one year and for A2 fractures at three years, compared to IMN. Otherwise no major difference in reoperation risk could be found between the two treatment methods when the fracture types were analysed individually (Table V).

Mortality

One-year mortality was lower for IMN compared to SHS for stable fractures (HRR: 0.87, 95% CI: 0.78 to 0.96, p=0.007), and for unstable fractures (HRR: 0.91, 95% CI: 0.84-0.98, p=0.014).

PROM data

Patients with unstable fractures treated with an SHS reported a lower EQ-5D-3L index score (0.55 vs 0.58, p=0.001), inferior walking ability based on the mobility dimension of the EQ-5D-3L (p<0.001), and were less satisfied with the result of the operation (mean VAS 33 vs.

30, $p<0.001$) than patients treated with an IMN (Table VI). The differences found in the EQ-5D-3L were persistent when calculating delta values. In patients with unstable fractures treated with SHS and IMN, respectively, 23% and 26% regained pre-fracture index score ($p=0.019$), while 53% and 60% regained pre-fracture walking ability ($p<0.001$).

Discussion

The results of this national register-based cohort study may indicate that IMN in the treatment of unstable fractures (A2, A3 and subtrochanteric fractures combined) is associated with lower reoperation rates than SHS. Infection and unspecified sequelae leading to THA were more prevalent causes of reoperation with the use of an SHS. We found similar reoperation rates for SHS and IMN in the treatment of A1 fractures, but peri-implant fracture was a more prevalent cause of reoperation in patients with A1 fracture treated with an IMN. Otherwise, there were no clinically relevant differences in individual fracture types between SHS and IMN in terms of reoperation rates or PROM data. There was however, a lower 1-year mortality rate in patients treated with IMN compared to SHS for stable and unstable fractures alike.

The most recent Cochrane review in 2010 recommended SHS for the majority of trochanteric fractures, mainly due to the higher incidence of peri-implant fractures associated with IMNs.[2] There were indications that IMNs may have advantages in the treatment of intertrochanteric fractures (A3) and subtrochanteric fractures, but further studies required. A recent propensity-matched comparative study of 8000 patients with A1, A2 and A3 fractures did not identify any major differences between SHS and IMN[6]. Similar results were reported in a multicentre randomized controlled trial (RCT) comparing SHS and IMN (InterTAN) in 684 patients with A1, A2, A3 and subtrochanteric fractures.[18]

In the present study we aimed to identify potential differences in reoperation rate between SHS and IMN in stable fractures (A1) and in unstable fractures (A2, A3 and subtrochanteric fractures combined) as such differences might be more clinically relevant and provide a more robust statistical analysis. In previous studies from the NHFR, lower reoperation rates have been found for SHS than for IMN in type A1 fractures one and three years postoperatively,[19] and higher reoperation rates for SHS compared to IMN in type A3 and subtrochanteric fractures combined.[8] A2 fractures were not included in these studies. In the present study we were unable to reproduce the differences in reoperation rate regarding individual fracture patterns, but we found a statistically significant lower risk of reoperation with the use of IMN in the treatment of the unstable fractures pooled together. Our results support the conclusion in a previous study from the NHFR that recommended the use of IMN in the treatment of A3 and subtrochanteric fractures.[8] In our study we included A2 fractures in the analysis of unstable fractures, thus also extending the recommendation to this group of fractures. Previous studies have highlighted only moderate to fair inter- and intraobserver reliability in the AO classification system regarding proximal femur fractures, particularly with regards to stability assessment of A2 fractures. This implies caution with use in day-to-day decision making or in register data interpretation.[15, 16]

Infection was a more prevalent cause of reoperation in patients with unstable fractures treated with SHS compared to those treated with IMN in our study. This also applied to the separate analysis of A2 and A3 fractures. Peri-implant fracture was a more prevalent cause of reoperation with the use of IMN in A1 fractures, but not in A2, A3 and subtrochanteric fractures individually or pooled together. Some authors claim that long nails reduce the risk of peri-implant fracture, but the literature is inconclusive regarding the protective effect of long versus short IMNs.[20] A3 and subtrochanteric fractures were almost exclusively treated with long nails/SHS with TSP and A1 fractures almost exclusively treated with short nails/regular

SHS. Therefore, we were not able to compare outcomes of long vs short nails in this study, nor variations between SHS vs SHS with TSP.

The high overall mortality in this population may pose a challenge in the statistical analyses. In the present article we focus on time to reoperation and we argue that the results from Cox regression are straight forward to interpret for these analyses. The statistical interpretation from Kaplan-Meier and Cox analysis for analysis of reoperation have been advocated.[21] Furthermore, using Fine and Gray models to condition on mortality may introduce collider bias and misinterpretation of the results.[22]

We found a lower mortality rate in patients treated with IMN compared to patients treated with SHS, applicable to stable and unstable fractures. This is contradictory to Whitehouse et al,[10] reporting a 12,5% increase in 30-day mortality risk after IMN. These results are not readily comparable. Our population was collected during a later period of time, the percentage of females was higher, we included both trochanteric and subtrochanteric fractures and we excluded pathological fractures.

The choice of implant is an important issue that affects patient outcomes, at least for certain groups of patients and fractures, but other factors might be even more important. More emphasis should probably be placed on fracture reduction, correct implant positioning and pre- and postoperative care to reduce reoperation rates and improve patient satisfaction[23]. Furthermore, economic considerations inevitably play a role in choice of implants in all fracture treatment.[24]

The EQ-5D-3L has been extensively studied and is regarded as a useful and relevant outcome measure for this patient population.[25, 26] We found a lower EQ-5D-3L index score at one year for patients with unstable fractures treated with an SHS compared to an IMN, and a lower VAS satisfaction score. Although the differences in mean EQ-5D-3L index score and mean VAS satisfaction score between the two groups were small, a sizable number of patients in one of the groups may still have reported a clinically significant better outcome. Accordingly, we performed additional analyses to identify the number of patients returning to their pre-fracture EQ-5D-3L score, VAS satisfaction score and walking ability, confirming the differences.

Strengths and limitations

Complications after a trochanteric or subtrochanteric fracture are rare, and large study populations are required to reveal statistically significant differences in implant performance or population characteristics. Some primary fracture patterns are uncommon, such as the A3 and the subtrochanteric fracture, and a sufficiently powered RCT is difficult to implement within a reasonable time frame. A large register-based study such as this one addresses some of these issues. In our study, patient characteristics at baseline were similar for the two groups, and selection bias unlikely. In the Norwegian health care system, the individual hospital chooses the implant, rather than the orthopaedic surgeon. This also reduces the risk of selection bias. Finally, register data from a national database describe the results of the average surgeon and hospital, and may reveal differences lost to RCTs performed in individual centres and by a limited number of surgeons.

This study has several limitations. Register-based studies such as the present can only describe associations, and do not aspire to prove causality. The completeness of registration of reoperations in the NHFR is lower than for primary operations,[12] at 80% versus 88%. Underreporting of complications is a possible bias, but we have no reason to suspect a difference in reporting between implants. IMNs and SHSs were assessed as two implant groups. Accordingly, our results might not apply equally to all implant dimensions and brands. Further, NHFR data do not provide radiological evidence of the primary fracture, and there might be classification errors obscuring the true complication rates of implants used to treat different fracture subgroups.[14-16] We have included all A2 fractures in the group of unstable fractures, as subclassification was not possible based on the NHFR data. A2-1 fractures are often considered stable, whereas the majority of A2 fractures are unstable and may pose as great a challenge to the orthopaedic surgeon as an A3 or subtrochanteric fracture. Additionally, combinations of fracture patterns are common but not mentioned in the NHFR data. Finally, analyses of PROM data must be used with caution. After one year, 24% of the study population had died, and only 52% of the remaining patients answered the questionnaire. With such a large amount of missing data we cannot draw any inferences based on PROM analyses, but we chose to still include these results as we have no reason to believe there are more non-responders in either group.

In conclusion, this national register-based study indicates a lower reoperation rate for IMN than SHS for unstable trochanteric and subtrochanteric fractures, but not for stable fractures or individual fracture types. The choice of implant may not be decisive to the outcome of treatment for stable trochanteric fractures in terms of reoperation rate. One-year mortality rate for unstable and stable fractures was lower in patients treated with IMN.

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Table I. Baseline characteristics of patients

	AO/OTA A1 fractures			AO/OTA A2 fractures			AO/OTA A3 fractures			Subtroch. fractures		
	SHS	IMN	**P-value**	**SHS**	**IMN**	**p-value**	**SHS**	**IMN**	**p-value**	**SHS**	**IMN**	**p-value**
Total number	4811	2030		4139	2975		407	645		473	1861	
Women, n (%)	3280 (68)	1399 (69)	0.55	3042 (74)	2187 (74)	0.99	307 (75)	494 (77)	0.67	355 (75)	1392 (75)	0.91
Mean age, yrs (SD)	83.0 (9.0)	83.0 (8.7)	0.99	83.5 (8.6)	83.3 (8.7)	0.48	83.6 (8.5)	82.9 (8.8)	0.18	82.4 (9.7)	82.2 (9.3)	0.71
Age groups, n (%)			0.022			0.91			0.46			0.068
60-74	924 (19)	347 (17)		692 (17)	515 (17)		67 (17)	123 (19)		114 (24)	406 (22)	
75-79	542 (11)	272 (13)		490 (12)	349 (12)		46 (11)	90 (14)		38 (8)	224 (12)	
80-84	922 (19)	389 (19)		779 (19)	548 (18)		68 (17)	103 (16)		76 (16)	341 (18)	
85-89	1153 (24)	517 (26)		1081 (26)	793 (27)		117 (29)	178 (28)		122 (26)	456 (25)	
> 90	1270 (26)	505 (25)		1100 (27)	770 (26)		109 (27)	151 (23)		123 (26)	434 (23)	
ASA class, n (%)			0.22			0.39			0.85			0.33
ASA 1	85 (2)	30 (2)		51 (1)	44 (2)		6 (2)	8 (1)		14 (3)	40 (2)	
ASA 2	1555 (32)	617 (30)		1261 (31)	911 (31)		118 (29)	199 (31)		146 (31)	571 (31)	
ASA 3	2794 (58)	1233 (61)		2483 (60)	1802 (61)		249 (61)	379 (59)		268 (57)	1109 (60)	
ASA 4	377 (8)	150 (7)		344 (8)	218 (7)		34 (8)	59 (9)		45 (10)	141 (8)	
Cognitive impairment (%)			0.007			0.029			0.88			0.70
Yes	1280 (27)	550 (27)		1137 (28)	748 (25)		104 (26)	161 (25)		117 (25)	420 (23)	
No	3010 (63)	1230 (61)		2537 (61)	1927 (65)		267 (66)	417 (65)		311 (66)	1255 (67)	
Uncertain	384 (8)	207 (10)		370 (9)	238 (8)		27 (7)	51 (8)		38 (8)	149 (8)	
Missing	137 (3)	43 (2)		95 (2)	62 (2)		9 (2)	16 (3)		7 (2)	37 (2)	
PROM preoperative, n	1981	875		1740	1280		182	301		216	810	
EQ-5D index score (SD)	0.71 (0.28)	0.70 (0.27)	0.45	0.72 (0.27)	0.71 (0.28)	0.18	0.69 (0.28)	0.74 (0.25)	0.034	0.71 (0.29)	0.74 (0.27)	0.17
Preoperative mobility (EQ-5D)			0.035			0.28			0.098			0.55
No problems	1142 (56)	463 (51)		1001 (56)	732 (56)		90 (48)	183 (58)		127 (58)	489 (58)	
Some problems	868 (43)	419 (47)		771 (43)	565 (43)		96 (51)	131 (41)		86 (39)	338 (40)	
Confined to bed	30 (2)	20 (2)		13 (1)	17 (1)		2 (1)	4 (1)		6 (3)	14 (2)	

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Table II. Number and type of reoperations

		AO/OTA A1 fractures		AO/OTA A2 fractures		AO/OTA A3 fractures		Subtroch. fractures	
	Total	**SHS**	**IMN**	**SHS**	**IMN**	**SHS**	**IMN**	**SHS**	**IMN**
N	17 341	4811	2030	4139	2975	407	645	473	1861
Reoperations 3 years, n (%)	982 (5.7)	159 (3.3)	67 (3.3)	303 (7.3)	182 (6.1)	46 (11.3)	63 (9.8)	36 (7.6)	126 (6.8)
Total joint replacement, n (%)	319 (1.8)	58 (1.2)	18 (0.9)	110 (2.7)	59 (2.0)	13 (3.2)	19 (2.9)	11 (2.3)	31 (1.7)
Bipolar hemiarthroplasty, n (%)	184 (1.2)	34 (0.7)	16 (0.8)	62 (1.5)	37 (1.2)	5 (1.2)	10 (1.6)	6 (1.3)	14 (0.8)
Re-osteosynthesis, n (%)	257 (1.5)	29 (0.6)	23 (1.1)	66 (1.6)	45 (1.5)	18 (4.4)	17 (2.6)	14 (3.0)	45 (2.4)
Soft tissue debridement, n (%)	106 (0.6)	26 (0.5)	3 (0.1)	40 (1.0)	13 (0.4)	7 (1.7)	5 (0.8)	0	12 (0.6)
Removal of implant, n (%)	86 (0.5)	12 (0.2)	2 (0.1)	26 (0.6)	19 (0.6)	3 (0.7))	7 (1.1)	1 (0.2)	16 (0.9)
Other, n (%)	121 (0.7)	19 (0.4)	6 (0.3)	38 (0.9)	22 (0.7)	6 (1.5)	11 (1.7)	6 (1.3)	13 (0.7)

>1 reoperation type may be performed per fracture

Table III. Cause of reoperation after stable fractures (AO/OTA A1) one and three years postoperatively, hierarchically arranged

	SHS, n (%)	IMN, n (%)	HRR*	95% CI	p
1 year postoperatively					
All reoperations	116 (2.4)	54 (2.7)	1.1	0.79 to 1.51	0.60
Infection	25 (0.5)	5 (0.2)	0.5	0.18 to 1.21	0.12
Peri-implant fracture	6 (0.1)	15 (0.7)	5.9	2.30 to 15.3	<0.001
Mechanical complications†	48 (1.0)	17 (0.8)	0.8	0.47 to 1.43	0.48
Unspecified sequelae (THA) ‡	33 (0.7)	11 (0.5)	0.8	0.40 to 1.56	0.49
Other reason§	4 (0.1)	4 (0.2)	2.4	0.61 to 9.78	0.21
Pain alone	0 (0)	2 (0.1)	-		
3 years postoperatively					
All reoperations	159 (3.3)	67 (3.3)	1.0	0.75 to 1.32	0.98
Infection	27 (0.6)	5 (0.2)	0.43	0.16 to 1.13	0.85
Peri-implant fracture	7 (0.1)	17 (0.8)	5.80	2.40 to 13.99	<0.001
Mechanical complications†	56 (1.2)	18 (0.9)	0.74	0.43 to 1.26	0.27
Unspecified sequelae (THA) ‡	56 (1.2)	18 (0.9)	0.78	0.46 to 1.32	0.35
Other reason§	7 (0.1)	6 (0.3)	2.07	0.70 to 6.16	0.19
Pain alone	6 (0.1)	3 (0.1)	1.22	0.31 to 4.88	0.78

*SHS is reference in Cox regression model adjusted for age, sex and ASA

† including hardware failure, cut-out, non-union

‡ Operation with THA recorded in the Norwegian Arthroplasty Register

§ All other reasons for reoperations except pain alone

Table IV. Cause of reoperation after unstable fractures (AO/OTA A2, AO/OTA A3 and subtrochanteric) one and three years postoperatively, hierarchically arranged

	SHS, n (%)	IMN, n (%)	HRR*	95% CI	p
1 year postoperatively					
All reoperations	290 (5.8)	270 (4.9)	0.82	0.70 to 0.97	0.022
Infection	53 (1.1)	34 (0.6)	0.6	0.38 to 0.90	0.016
Peri-implant fracture	16 (0.3)	23 (0.4)	1.3	0.69 to 2.46	0.43
Mechanical complications†	132 (2.6)	127 (2.3)	0.9	0.85 to 1.09	0.19
Unspecified sequelae (THA) ‡	81 (1.6)	57 (1.0)	0.6	0.43 to 0.85	0.003
Other reason§	8 (0.2)	17 (0.3)	1.9	0.83 to 4.46	0.13
Pain alone	0 (0)	12 (0.2)	-		
3 years postoperatively					
All reoperations	385 (7.7)	371 (6.8)	0.86	0.74 to 0.99	0.036
Infection	55 (1.1)	34 (0.6)	0.57	0.37 to 0.87	0.009
Peri-implant fracture	20 (0.4)	36 (0.7)	1.66	0.96 to 2.87	0.07
Mechanical complications†	150 (3.0)	153 (2.8)	0.91	0.72 to 1.14	0.39
Unspecified sequelae (THA) ‡	130 (2.6)	100 (1.8)	0.67	0.52 to 0.88	0.003
Other reason§	12 (0.2)	22 (0.4)	1.66	0.82 to 3.36	0.16
Pain alone	18 (0.4)	26 (0.5)	1.27	0.69 to 2.31	0.44

*SHS is reference in Cox regression model adjusted for age, sex and ASA

† including hardware failure, cut-out, non-union

‡ Operation with THA recorded in the Norwegian Arthroplasty Register

§ All other reasons for reoperations except pain alone

Table V. Risk of reoperation for SHS and IMN for AO/OTA A1, A2, A3 and subtrochanteric fractures individually

	SHS		IMN				
	n	**Reoperation, n**	**n**	**Reoperation, n**	**HRR***	**95% CI**	**p-value**
Reoperations one year							
AO/OTA A1	4811	116	2030	54	1.1	0.79 to 1.51	0.6
AO/OTA A2	4139	221	2975	135	0.83	0.67 to 1.03	0.093
AO/OTA A3	407	41	645	45	0.65	0.43 to 1.00	0.050
Subtrochanteric fractures	473	28	1861	90	0.79	0.52 to 1.21	0.28
Reoperations three years							
AO/OTA A1	4811	159	2030	67	1.0	0.75 to 1.32	0.98
AO/OTA A2	4139	303	2975	182	0.83	0.69 to 1.00	0.050
AO/OTA A3	407	46	645	63	0.83	0.57 to 1.21	0.33
Subtrochanteric fractures	473	36	1861	126	0.89	0.61 to 1.29	0.54

* Hazard rate ratio calculated using Cox regression with SHS as reference. Adjusted for age, sex and ASA

Table VI. Pain, satisfaction and quality of life 12 months after primary operation

	SHS	IMN	Mean difference (95% CI)	p-value
Mean EQ-5D-3L index score				
Stable fractures	0.59 (n=1746)	0.58 (n=692)	0.01 (-0.02 to 0.02)	0.96
Unstable fractures	0.55 (n=1776)	0.58 (n=2052)	-0.04 (-0.05 to -0.02)	**<0.001**
EQ-5D-3L: mobility for stable fractures				0.505
No problems	26.9% (n=485)	29.1% (n=211)		
Some problems	68.9% (n=1243)	66.6% (n=482)		
Confined to bed	4.3% (n=77)	4.3% (n=31)		
EQ-5D-3L: mobility for unstable fractures				**<0.001**
No problems	20.4% (n=377)	26.6% (n=571)		
Some problems	74.3% (n=1372)	69.4% (n=1488)		
Confined to bed	5.3% (n=97)	3.9% (n=84)		
Mean VAS score for pain				
Stable fractures	24.2 (n=1777)	24.3 (n=704)	-0.1 (-1.9 to 1.7)	0.91
Unstable fractures	27.3 (n=1820)	25.8 (n=2104)	1.5 (0.2 to 2.8)	0.029
Mean VAS score for satisfaction				
Stable fractures	27.9 (n=1773)	27.5 (n=710)	0.5 (-1.4 to 2.3)	0.63
Unstable fractures	32.5 (n=1821)	30.0 (n=2110)	2.5 (1.1 to 4.0)	**<0.001**

Fig 1. Flowchart of the study population

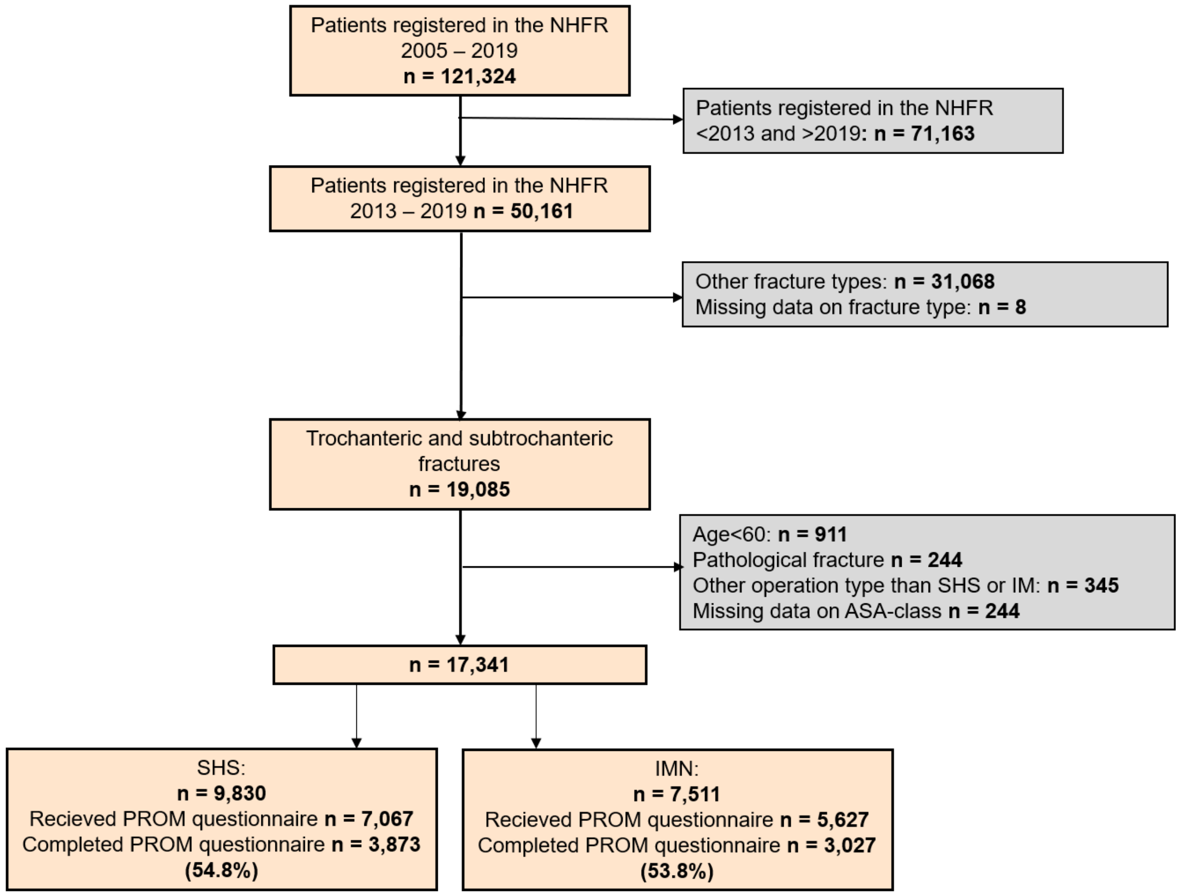

Fig 2. Implant survival curves for SHS and IMN in stable (AO/OTA A1) fractures versus unstable (A2, A3 and subtrochanteric) fractures