

Comparison of Short and Long Intramedullary Nails in the Treatment of Trochanteric and Subtrochanteric Fractures

An Observational Study of 17,606 Fractures in the Norwegian Hip Fracture Register

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Background: There is no consensus of whether to use a short or long intramedullary nail (IMN) in the treatment of trochanteric and subtrochanteric fractures.

Methods: In this retrospective cohort study, we analyzed 17,606 trochanteric and subtrochanteric fractures treated with an IMN registered in the Norwegian Hip Fracture Register from 2008 to 2022. The primary outcome was overall 1-year reoperation risk, and secondary outcomes were reoperation risk for specific causes and 1-year mortality for short IMNs (SIMNs) and long IMNs (LIMNs) and to compare 1-year reoperation risk for short and long versions of the 2 most used brands (Gamma3 and TRIGEN INTERTAN). Cox regression analyses adjusted for age, sex, and ASA class and instrument variable (IV) analyses with operation year and hospital as instrument were performed to calculate hazard rate ratios (HRRs).

Results: LIMNs had a statistically significant higher reoperation risk than SIMNs in A1 fractures in the IV analysis. No other statistically significant differences in overall 1-year reoperation risk or 1-year mortality between SIMNs and LIMNs were found for any of the fracture types. Infection was a more frequent cause of reoperation after LIMNs (HRR, 2.82 [95% confidence interval [CI], 1.53-5.20]) while peri-implant fractures were less common for LIMNs (HRR, 0.38 [95% CI, 0.20-0.75]) compared with SIMNs. No statistically significant differences were found in reoperation risk between short and long Gamma3 nails or TRIGEN INTERTAN nails.

Conclusion: SIMNs performed equal or better than LIMNs for all types of trochanteric and subtrochanteric fractures.

Level of Evidence: Therapeutic Level III. See instructions for Authors for a complete description of levels of evidence.

Introduction

In the last decade, treatment of trochanteric and subtrochanteric fractures has skewed towards intramedullary nails (IMNs) at the expense of sliding hip screws, especially in fractures with unstable patterns^{1,2}. According to national guidelines short intramedullary nails (SIMNs) are preferred in AO Foundation/Orthopaedic Trauma Association (AO/OTA) A1 and A2 fractures³, while long intramedullary nails (LIMNs) are preferred in AO/OTA A3 and in subtrochanteric fractures⁴⁻⁶. Advantages of a SIMN is that the implant is less expensive and that the surgical procedure is simpler with no need for intramedullary reaming, the possibility of

distal locking through a targeting jig, and reduced operating time compared with a LIMN. On the other hand, a LIMN may provide improved stability⁶. Multiple small studies have shown little to no difference between LIMNs and SIMNs⁷⁻¹⁵. A recent Danish multicenter cohort study, however, has reported fewer reoperations after LIMNs for subtrochanteric fractures and after SIMNs for trochanteric fractures¹⁶. That study, together with a systematic review comparing LIMN and SIMN, has called for further research with larger study populations^{7,16}. In Norway, all hip fracture operations have been prospectively registered in the Norwegian Hip Fracture Register (NHFR) since 2005¹⁷. Using data in the

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (<http://links.lww.com/JBJSOA/A940>).

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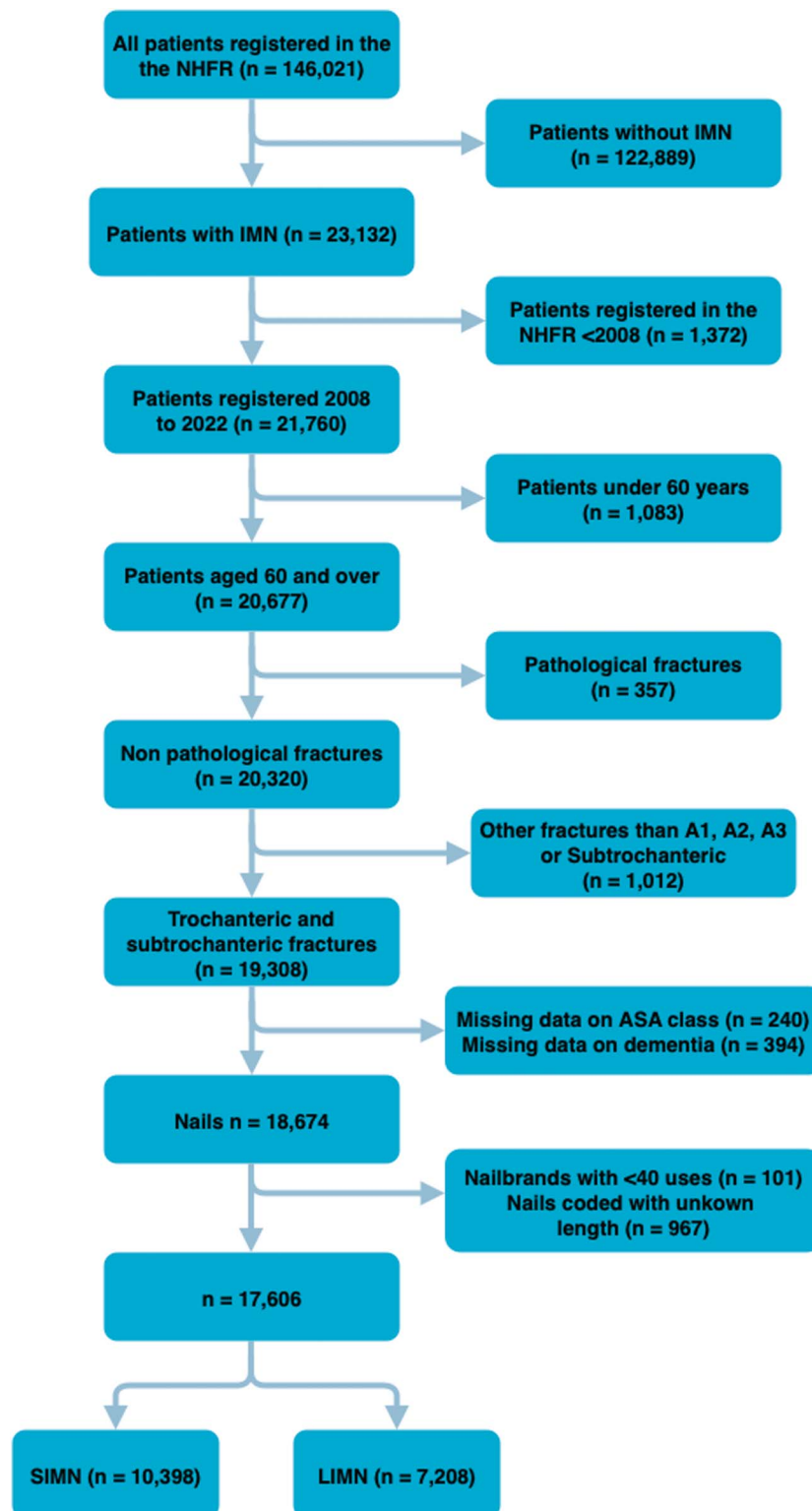


Fig. 1
Flowchart of study population.

NHFR, our primary aim was to compare 1-year reoperation risk between SIMNs and LIMNs for different trochanteric and subtrochanteric fractures. Secondary aims were to evaluate reopera-

tion risk of specific causes and 1-year mortality between SIMNs and LIMNs and to compare short and long versions of the 2 most used brands (Gamma3 and TRIGEN INTERTAN).

Materials and Methods

We used data from the NHFR with 86% completeness for primary osteosyntheses¹⁸. Surgeons reported details regarding the patient, the fracture type, and the operation. By use of stickers provided by the manufacturers detailed information of the individual implants, including brand name, diameter, and length was registered. This information was used to categorize implants as SIMN or LIMN. All SIMNs had a length of 24 cm or shorter and could be distally locked through a targeting jig. Some brands had SIMNs with a length of 23.5 to 24 cm. These “intermediate” nails were categorized as SIMNs. Trochanteric fractures were classified using the AO/OTA classification system as A1 (Two-part fracture), A2 (Multifragmentary fracture), and A3 (Intertrochanteric (reverse oblique) fracture)³. Subtrochanteric fractures were defined as fractures with a main fracture line between the distal limit of the lesser trochanter and the proximal 5 cm of the femoral shaft. Intraoperative surgical complications such as difficulties in reducing the fracture, excessive bleeding, and technical problems with implants or instruments were reported by the surgeon. Cause and type of eventual reoperations were also registered. Reoperations with a total hip arthroplasty were registered in the Norwegian Arthroplasty Register (NAR) but were later included in the data files of the NHFR. The latter reoperations with a THA were in the NAR classified as unspecified sequela after proximal femoral fracture and accordingly, we do not know the exact reason for these reoperations. Surgeons could choose more than 1 cause for each reoperation. A hierarchy identifying the most severe cause were used, making sure each reoperation only counted once: infection, peri-implant fracture, mechanical complications, malunion/nonunion, unspecified sequela treated with total hip arthroplasty, other, and lastly pain alone. ASA class¹⁹ was divided into 2 subgroups: ASA 1 to 2 and ASA 3 to 5. The Norwegian National Population Register provided information on time of death.

The AO/OTA classification of trochanteric fractures was included in the NHFR from 2008. Therefore, we included trochanteric and subtrochanteric fractures treated with an IMN between January 1, 2008, and December 31, 2022. Inclusion and exclusion criteria are shown in detail in Fig. 1.

Statistical Analysis

We analyzed baseline data using the chi-squared test for categorical variables and independent-samples t-test for continuous variables. For risk of reoperation and cause of reoperation, hazard rate ratios (HRRs) with 95% confidence intervals (CIs) and survival curves were calculated using Cox regression analysis, adjusting for age, sex, and ASA classification. There were some deviations in the proportionality assumptions in the Cox regression models when investigated the survival curves visually and with log minus log plots. Hence, the coefficients from the Cox models should be interpreted with care. We ran subanalyses of different fracture types for the most used brands, Gamma3 (Stryker) and TRIGEN INTERTAN (Smith & Nephew) which had been used throughout the study period and had >1,000 reported operations in both the LIMN and the SIMN group. Finally, we ran separate subanalyses including only ASA 1 to 2

TABLE 1 Baseline Characteristics of Patients

	SIMN	LIMN	p
Total number (no. [%])	10,398 (59.1)	7,208 (40.9)	
Female (no. [%])	7,375 (70.9)	5,291 (73.4)	<0.001
Age* (yr)	83.1 (8.6)	82.63 (9.0)	<0.001
Age groups (no. [%])			<0.001
60-69 yr	888 (8.5)	751 (10.4)	
70-79 yr	2,245 (21.6)	1,643 (22.8)	
80-89 yr	4,709 (45.3)	3,059 (42.4)	
90 yr or older	2,556 (24.6)	1,755 (24.3)	
ASA class (no. [%])			0.253
1-2	3,262 (31.4)	2,320 (32.2)	
3-5	7,136 (68.6)	4,888 (67.8)	
Dementia (no. [%])			<0.001
Yes	2,890 (27.8)	1,813 (25.2)	
No	6,492 (62.4)	4,815 (66.8)	
Uncertain	1,016 (9.8)	580 (8.0)	
Fracture type (no. [%])			<0.001
AO/OTA A1	4,451 (42.8)	441 (6.1)	
AO/OTA A2	5,119 (49.2)	2,558 (35.5)	
AO/OTA A3	427 (4.1)	921 (12.8)	
Subtrochanteric	401 (3.9)	3,288 (45.6)	

ASA = American Society of Anesthesiologists, AO/OTA = AO Foundation/Orthopaedic Trauma Association, LIMN = long intramedullary nail, and SIMN = short intramedullary nail. *The values are given as the mean and standard deviation.

patients, women, and patients treated in 3 different periods (2008-2011, 2012-2016, and 2017-2022). Patients were followed from primary operation to reoperation, death, or December 31, 2022. For mortality, HRRs with CIs were calculated using Cox regression analysis, adjusting for age, sex, ASA classification, and fracture type. Fine and Gray regression analyses calculating subhazards with death as a competing risk of reoperation²⁰ were performed. In addition, we investigated any difference between the 2 groups using instrumental variable (IV) analyses in a Cox regression model as described by Mackenzie et al.²¹. Confounding adjustment was performed through the instrument (year of operation and hospital) assuming that the hospitals were related to reoperation risk only through their choice of treatment, SIMN or LIMN, for each year, and that the hospital was independent of unobserved covariates. IBM SPSS Statistics (v. 29, IBM) and the R statistical package (R Foundation for Statistical Computing) were used to perform statistical analysis.

Results

Of 17,606 included fractures, 10,398 were treated with a SIMN and 7,208 were treated with a LIMN. The annual numbers of SIMNs and LIMNs and the percentage of SIMNs used in the respective fracture types are shown in Supplementary Fig. 1. The use of both IMNs has increased, with LIMNs taking a bigger share (23.8% in 2008, 47.5% in 2022).

Baseline data of the 2 groups are shown in Table I. Perioperative data are shown in Table II. The most pronounced difference between the 2 groups was the higher mean operating time for LIMNs compared with SIMNs (92.1 vs. 52.2 minutes, respectively). Most short PFNA nails (N = 901) were “intermediate” nails with a length of 24 cm. The short TFNA nails were almost exclusively “intermediate” nails with a length of 23.5 cm (N = 385) (Table II). Most “intermediate” nails were used in A1 and A2 fractures (75% and 91% of PFNA and TFNA, respectively).

Reoperations

The overall reoperation rate was 5.0% for SIMNs and 6.0% for LIMNs. There were no statistically significant differences in

reoperation risk between SIMNs and LIMNs for any of the fracture types (Table III). In the IV-analyses, LIMNs had a higher 1-year and overall risk of reoperation than SIMNs for A1-fractures. The most frequent causes of reoperation were infection (N = 5, 27.8%) and mechanical complication (N = 4, 22.2%) for LIMNs, and peri-implant fracture (N = 33, 19.9%) and mechanical complication (N = 30, 18.1%) for SIMNs. For A2, A3, and subtrochanteric fractures IV-analysis confirmed the results from the adjusted Cox analyses (Supplementary Table 1). Fig. 2 shows the implant survival for SIMNs and LIMNs for each fracture type.

The causes of reoperations for SIMN and LIMN are presented in Supplementary Fig. 2. LIMNs were less frequently

TABLE II Perioperative Data

	SIMN	LIMN	p
Total number (no. [%])	10,398 (59.1)	7,208 (40.9)	
Surgeon experience* (no. [%])			<0.001
<3 yrs	1,393 (13.4)	476 (6.6)	
>3 yrs	7,055 (67.8)	5,878 (81.5)	
Missing	1,950 (18.8)	854 (11.8)	
Duration of surgery† (min)	52.2 (24.0)	92.1 (44.9)	<0.001
Type of anesthesia (no. [%])			<0.001
General	1,320 (12.7)	1,193 (16.6)	
Spinal	8,720 (83.9)	5,677 (78.8)	
Other	261 (2.5)	286 (4.0)	
Missing	97 (0.9)	52 (0.7)	
Antibiotic prophylaxis (no. [%])			<0.001
Yes	10,067 (96.8)	7,142 (99.1)	
No	280 (2.7)	45 (0.6)	
Missing	51 (0.5)	21 (0.3)	
Intraoperative complications (no. [%])			<0.001
Yes	272 (2.6)	294 (4.1)	
No	9,792 (94.2)	6,721 (93.2)	
Missing	334 (3.2)	193 (2.7)	
Distally locked (no. [%])			
Yes	10,152 (97.6)	7,094 (98.4)	
No	246 (2.4)	114 (1.6)	
Nail brand‡ (no. [%])			
Gamma3 (Stryker)	6,084 (58.5)	3,537 (49.1)	
TRIGEN INTERTAN (Smith & Nephew)¶	2,702 (26.0)	2,473 (34.3)	
PFNA (DePuy Synthes)¶	1,188 (11.4)	214 (3.0)	
TFNA (DePuy Synthes)¶	386 (3.7)	155 (2.2)	
TRIGEN TAN/FAN (Smith & Nephew)	0 (0.0)	375 (5.2)	
T2 recon (Stryker)	0 (0.0)	358 (5.0)	
AFFIXUS (Zimmer Biomet)	38 (0.4)	39 (0.5)	
LFN (DePuy Synthes)	0 (0.0)	57 (0.8)	

SIMN = short intramedullary nail, and LIMN = long intramedullary nail. *Only registered since 2011. †The values are given as the mean and SD. ‡8 brands used in >40 operations as either SIMN or LIMN. ¶“Intermediate” nails with lengths 23.5 to 24 cm are included in SIMN. TRIGEN INTERTAN: 24 nails (0.9% of SIMN), PFNA: 901 nails (75.8% of SIMN), TFNA: 385 nails (99.7% of SIMN).

TABLE III Reoperations at 1 Year and Overall: Short and Long Nails

	SIMN		LIMN		Cox Analysis		Fine and Gray Analysis	
	Total No. of Nails	Reoperations (No. [%])	Total No. of Nails	Reoperations (No. [%])	HRR* (95% CI)	p*	SubHRR† (95% CI)	p†
1 yr								
AO/OTA A1	4,451	111 (2.5)	441	14 (3.2)	1.33 (0.76-2.32)	0.316	1.29 (0.74-2.3)	0.360
AO/OTA A2	5,119	213 (4.2)	2,558	98 (3.8)	0.95 (0.75-1.21)	0.664	0.92 (0.73-1.71)	0.510
AO/OTA A3	427	26 (6.1)	921	51 (5.5)	0.89 (0.55-1.43)	0.619	0.88 (0.55-1.41)	0.590
Subtrochanteric	401	13 (3.2)	3,288	136 (4.1)	1.28 (0.72-2.26)	0.399	1.26 (0.72-2.22)	0.420
Overall								
AO/OTA A1	4,451	166 (3.7)	441	18 (4.1)	1.20 (0.74-1.96)	0.457	1.14 (0.68-1.82)	0.670
AO/OTA A2	5,119	306 (6.0)	2,558	128 (5.0)	0.90 (0.73-1.10)	0.290	0.83 (0.68-1.02)	0.077
AO/OTA A3	427	31 (7.3)	921	81 (8.8)	1.20 (0.79-1.82)	0.392	1.15 (0.75-1.74)	0.530
Subtrochanteric	401	21 (5.2)	3,288	206 (6.3)	1.22 (0.78-1.92)	0.380	1.16 (0.75-1.81)	0.510

AO/OTA, AO Foundation/Orthopaedic Trauma Association, LIMN = long intramedullary nail, and SIMN = short intramedullary nail. *Cox analysis adjusted for sex, age, and ASA class. SIMN is the reference. †Fine and Gray analysis adjusted for sex, age, and ASA class. Death as a competing risk. SIMN is the reference.

reoperated due to peri-implant fracture (HRR 0.38 [95% CI, 0.20-0.75]), but more frequently reoperated due to infection (HRR 2.82 [95% CI, 1.53-5.20]) compared with SIMNs. For PFNA, the only brand with a substantial number of both traditional short nails and “intermediate” nails, there were 0.7% peri-implant fractures with traditional short nails (2 out of 287) and 1.2% (11 out of 901) with “intermediate” nails.

In subanalyses including only ASA 1 to 2 patients, women or patients treated in 3 different periods, no statistically significant differences reoperation risk between SIMN and LIMN could be found, neither for all fractures nor for individual fracture types (data not shown).

In subanalyses including the 2 most used brands (Gamma3 and TRIGEN INTERTAN), no differences in 1-year reoperation risk for any fracture type were found between short and long versions of each nail brand (Supplementary Table 2).

Mortality

Thirty-day and 1-year mortality for all patients was 8.6% and 24.6%, respectively. There were no statistically significant differences in 30-day (HRR 0.96 [95% CI: 0.84-1.09]) and 1-year mortality (HRR 0.97 [95% CI: 0.90-1.04]) between SIMNs and LIMNs. No statistically significant differences were found in mortality between SIMNs and LIMNs for any of the fracture types (data not shown).

Discussion

This national, register-based observational study found no statistically significant differences in reoperation risk between SIMNs and LIMNs in the treatment of A2, A3, and subtrochanteric fractures. In IV-analysis, we found LIMNs to have a higher reoperation risk in A1 fractures. There were no statistically significant differences in mortality between SIMNs and LIMNs for any fracture type. Peri-implant fracture was a more common

cause of reoperation for SIMNs, while reoperation due to infection occurred more frequently after treatment with LIMNs. Our reoperation rates are comparable with those found in earlier studies^{7,16,22}. The causes of reoperation found in our study are also comparable with findings of some earlier studies, where infections have been found to be more common after LIMNs whereas SIMNs more often are reoperated due to peri-implant fractures^{7,10,16}.

Peri-implant fracture is a well-known complication with SIMNs, but may also occur following LIMNs²³. In this study, there were more peri-implant fractures after SIMNs (0.8%) than after LIMNs (0.4%). The “intermediate” SIMNs did not seem to protect against peri-implant fracture. While a fracture below a SIMN may be treated with a LIMN, treatment of a fracture below the tip of a LIMN may be more challenging. The increased risk of infection following a LIMN may be attributed to a more complex fracture pattern that increases blood loss and necessitates open reduction and a more invasive approach. In addition, the need for intramedullary reaming and distal locking with use of image intensifier instead of a targeting jig increase operation time.

One biomechanical study found that a SIMN might lead to a varus deformity postoperatively in A3.3 fractures but that this can be avoided with 2 interlocking screws or larger nail diameter²⁴. Other biomechanical studies have shown no difference in failure rates in A3 and subtrochanteric fractures between SIMNs and LIMNs²⁵⁻²⁸. Chantarapanich et al. concluded that a SIMN with 2 distal locking screws is biomechanical sufficient in high subtrochanteric fractures²⁵. Femoral anteversion vary with ethnicity, age, and femoral length²⁹. As older patients may have an increased curvature of the femur there is a risk for anterior perforation of the nail tip in the distal femur. Accordingly, some surgeons may be reluctant to use LIMNs in older patients.

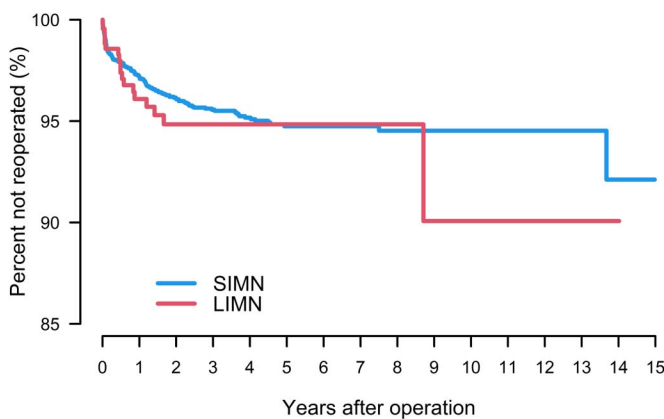


Fig. 2-A

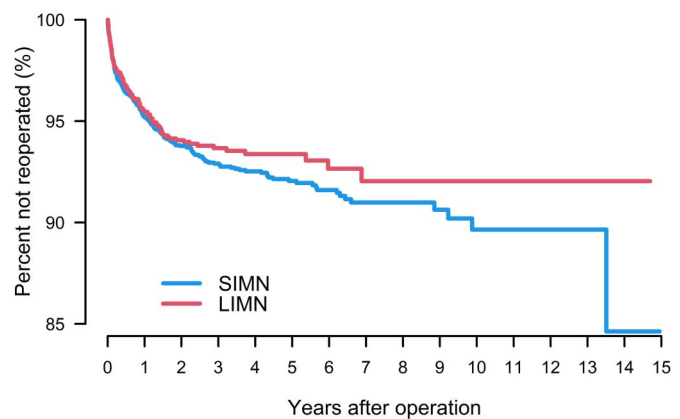


Fig. 2-B

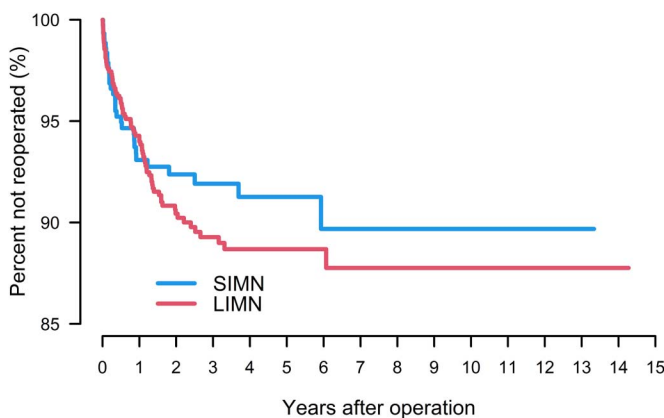


Fig. 2-C

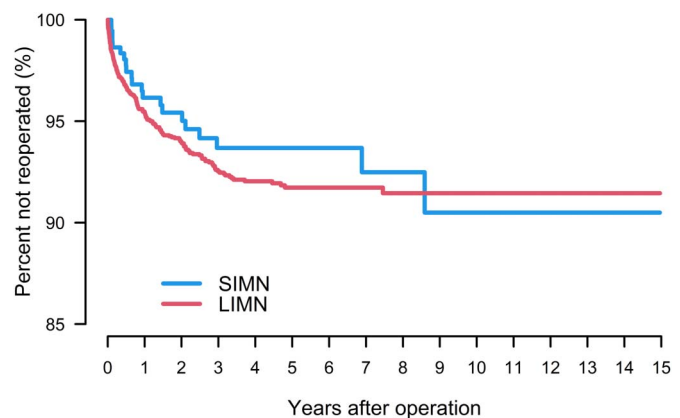


Fig. 2-D

Figs 2-A through 2-D Survival curves for short and long intramedullary nails as treatment for trochanteric AO/OTA A1, A2, A3, and subtrochanteric fractures with any cause of reoperation as endpoint. Cox regression analyses with adjustments for sex, age, and ASA class. **Fig. 2-A** AO/OTA A1. **Fig. 2-B** AO/OTA A2. **Fig. 2-C** AO/OTA A3. **Fig. 2-D** Subtrochanteric. AO/OTA = AO Foundation/Orthopaedic Trauma Association, LIMN = long intramedullary nail, and SIMN = short intramedullary nail.

Strength and Limitations

The major strength of our study is the large study population. Using the NHFR database, we have access to nationwide results with 100% coverage of Norwegian hospitals making our results highly generalizable. The NHFR has 86% completeness for primary osteosyntheses and a high data quality¹⁸. Finally, it is a strength that implants were registered and categorized into SIMNs and LIMNs based on catalogue numbers supplied by the manufacturers.

The study also has several limitations. Completeness of reoperations in the NHFR is lower than for primary operations (72%)¹⁸. There is, however, no reason to suspect that the completeness of reporting of reoperations is different for SIMNs and LIMNs, and the completeness is unlikely to affect the HRRs presented. We had no access to radiographs, and validation of surgeons' classification of fractures was thus not possible. There is also a risk that LIMNs within each fracture group have been used to treat more unstable fractures with more comminution or more distally extension than fractures treated with SIMNs. In the IV-analyses, LIMNs had higher

reoperation risk than SIMNs. This can possibly be explained by use of sliding hip screws in place of SIMNs at several Norwegian hospitals. Most importantly, without available radiographs, we had no information on implant positioning and fracture reduction, factors that may influence risk of reoperation.

Clinical Implications of the Results

The only difference found between SIMNs and LIMNs for different types of trochanteric and subtrochanteric fractures was a higher risk of reoperation for AO/OTA A1 fractures treated with a LIMN in the IV analysis. Factors not adjusted for in the present study, such as reduction of the fracture and implant positioning, probably influence the risk for reoperation, and focus on surgical details may be more important than the implant itself. Optimal positioning of the lag screw, i.e., avoiding anterior or posterior placement, and a tip apex distance less than 25 mm, has been shown to reduce risk of reoperation^{30,31}. With correct surgical technique a SIMN may be sufficient for most trochanteric fractures. However, even if our

results show no benefit of using a LIMN, there is a need for further research on this topic, preferably a large-scale randomized controlled trial (RCT) or a register-RCT. While SIMN appeared to be safe also for subtrochanteric fractures in our study, there is still concern that distal extension of these fractures may be an indication for conversion to a LIMN.

Conclusion

For AO/OTA A1 fractures, LIMNs had a statistically significant higher risk of reoperation compared with SIMNs. Otherwise, no statistically significant differences in all-cause reoperation risk or mortality between short and long intramedullary nails in the treatment of different types of trochanteric and subtrochanteric fractures were found. Based on this registry-based study, a SIMN seems to be a safe treatment option also for fractures with unstable patterns. However, the role of SIMNs for trochanteric and subtrochanteric fractures with distal extension should be further investigated.

Appendix

 Supporting material provided by the authors is posted with the online version of this article as a data supplement at [jbjs.org \(http://links.lww.com/JBJSOA/A941\)](http://links.lww.com/JBJSOA/A941). This content was not copyedited or verified by JBJS. ■

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