

Increased mortality after intramedullary nailing of trochanteric fractures: a comparison of sliding hip screws with nails in 19,935 patients

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Submitted 2021-06-28. Accepted 2021-11-01.

Background and purpose — Intramedullary nails (IMN) have become increasingly common as treatment for trochanteric hip fractures (THF) although they are costlier, and without proven superiority compared with sliding hip screws (SHS). We investigated whether the 2 methods differ in terms of short-term mortality when used in fractures where both methods are suitable.

Patients and methods — We extracted data from the Swedish Fracture Register (SFR) on 19,935 patients \geq 60 years with trochanteric fractures AO type 31-A1 or -A2 who had been treated with either SHS or IMN. We assessed absolute mortality rates and the relative risks (RR) of death after 7, 30, 90, and 365 days using generalized linear models, adjusting for age, sex, and fracture type. We performed a sensitivity analysis on a subgroup of 3,673 patients with information on comorbidity to address this potential confounder.

Results — 69% of the patients were women and mean age was 84 years (60–107). IMN was used in 35% of A1 and in 71% of A2 fractures. The use of IMN was associated with a slightly increased adjusted risk of death within 30 days compared with SHS (RR = 1.1, 95% CI 1.0–1.2) with no difference at any other time point.

Interpretation — The slightly increased risk of death up to 30 days postoperatively does not support the use of IMN instead of SHS in stable THF.

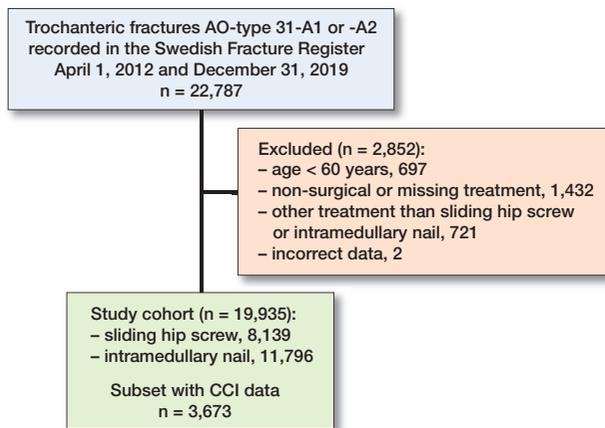
The choice of implant for trochanteric hip fractures (THF) differs depending on fracture classification, national traditions, experience, and case load (1). When classified according to AO/OTA, the standard surgical treatment for the simple 2-fragment (A1) and the less stable, multifragmentary (A2) fractures is by use of either extramedullary sliding hip screws (SHS) or intramedullary nails (IMN) (2,3). The highly unstable reverse oblique or subtrochanteric (A3) fractures are mostly treated by IMN (2).

The use of IMN has increased even in stable A1 fractures (3,4). The extramedullary SHS may need a more extensive surgical approach and is associated with longer procedural time (5), whereas the IMN may be inserted through smaller incisions (3,6) as long as the fracture does not need open reduction. Conflicting results have been published regarding the potential benefits and drawbacks of IMN used for trochanteric fractures, and there is little evidence for a better outcome regarding fracture healing, complications, or function after the use of IMN in A1 and A2 fractures (2,5).

Moreover, regarding mortality, 2 studies from the UK contradict each other: one found higher mortality after SHS for unstable A2 and A3 fractures (7), and the other found SHS to be associated with lower mortality (6).

Considering the increasing use of IMN also in stable fracture configurations (8) and the large differences in the choice of these concepts between centers (9), it is reasonable to question a trend that seems not to be justified by superior short-term outcomes. In addition, the IMN is more expensive than the SHS (3).

This observational study from the Swedish Fracture Register (SFR) compares the risk of death after the use of SHS or IMN in patients with fractures amenable to both treatment types, i.e., the more stable A1 and the less stable A2-type THF.



Patients included in the study.

Patients and methods

Study design and variables

This is an observational longitudinal cohort study of prospectively collected register data on patients with THF treated either with an SHS or an IMN. We retrieved data from the SFR on all patients ≥ 60 years at injury registered with a THF (International Classification of Diseases [ICD] S72.1) between April 1, 2012 and December 31, 2019. Coverage and completeness increased during the study period. In 2019, the overall national completeness compared with the National Patient Register (NPR) was 65%. 24 of the 45 active units had $> 80\%$ completeness. The SFR was implemented stepwise with 1 department in 2011 to 45 of the 54 orthopedic departments in Sweden in 2019, with full coverage by January 2021. Retrieved information included age, sex, injury mechanism (including low- or high-energy), fracture type (AO/OTA 2-fragment 31-A1 or multi-fragmentary 31-A2 fracture), and details on the treatment method (SHS, or short or long IMN) (10). The fractures were classified (11) by the treating surgeon. Intertrochanteric fractures including reverse oblique 31-A3 fractures were excluded.

The SFR is linked with the Swedish Tax Agency to obtain data on mortality, and each individual is traceable due to the Swedish personal identity numbers.

Patients were divided into age groups: 60–74, 75–84, and ≥ 85 . A subgroup of our cohort consisting of 3,673 patients (registered before December 31, 2014) had been matched with the NPR to collect data on comorbidities. The retrieved ICD codes 12 months prior to the fracture were used to calculate the Charlson Comorbidity Index (CCI), modified according to Quan et al. (12). These comorbidities were categorized into 3 groups: CCI 0, CCI 1–2, and CCI ≥ 3 , representing no, moderate, and high comorbidity, respectively. To avoid dependency issues, we included only data concerning the first fracture in patients with a subsequent femoral fracture during the study period. Patients < 60 years, those treated non-surgically or

using other surgical methods than SHS or IMN, and patients with obviously incorrect dates (deceased before injury) were excluded (Figure). We followed the STROBE guidelines for the reporting of observational studies.

Outcome measures

The main outcome measure was death within 30 days of injury. Secondary outcome measures were death 7, 90, and 365 days following injury. Absolute mortality rates and relative risks (RR) comparing effects of fracture type, age group, sex, and treatment method (SHS vs. IMN) were calculated.

Statistics

Balance between treatment groups was assessed using descriptive statistics. Crude mortality was calculated for each treatment method at 7, 30, 90, and 365 days. Adjusted relative risks (RR) including 95% confidence intervals (CI) were estimated based on a generalized linear model with log-link including the confounders fracture type, age group, and sex. Similar separate analyses were performed for the smaller cohort also including CCI. Statistical analyses were performed using SAS (v9.4) (SAS Institute, Cary, NC, USA) and R v4.0.2 (R Foundation for Statistical computing, Vienna, Austria).

Ethics, funding, data sharing, and potential conflict of interest

Ethical approval was granted by the Regional Ethical Committee in Uppsala (Dnr 2015/510 and 2020/05439). We followed the ethical principles of the Helsinki Declaration. No specific grants were received for this study. Data can be made available on reasonable request to the corresponding author. The authors declare no competing interests.

Results

Characteristics of the study population

The study cohort consisted of 19,935 patients with a type AO 31-A1 or -A2 THF. 69% were women and the mean age was 84 years (60–107). 41% had an SHS and 59% an IMN (Table 1). 1/3 of the fractures were classified as stable trochanteric (A1) and 2/3 unstable (A2). IMN was used in 35% of A1 and in 71% of A2 fractures. Long IMNs were used in 9% and 18% of all IMN for A1 and A2 fractures.

Mortality

Crude mortality rates for all patients were 2.5% at 7 days, 8.4% at 30 days, 15% at 90 days, and 27% at 365 days (Table 2). The adjusted risk of death within 30 days was higher among patients treated with IMN than among those treated with SHS (RR 1.1, CI 1.0–1.2) (Table 3). There was no statistically significant difference in the adjusted risk of death depending on treatment method at any other time point.

Table 1. Descriptive statistics on 19,935 patients with trochanteric hip fractures treated with either sliding hip screws (SHS) or intramedullary nails (IMN). Values are count (%) unless otherwise specified

Factor	SHS (n = 8,139)	IMN (n = 11,796)	SMD
Age, mean (SD)	83 (9)	84 (8)	0.04
Age group			0.04
≥ 85	4,123 (51)	6,213 (53)	
75–84	2,689 (33)	3,765 (32)	
60–74	1,327 (16)	1,818 (15)	
Women	5,458 (67)	8,392 (71)	0.09
Injury type ^a			0.07
High energy	43 (0.6)	87 (0.8)	
Low energy	7,591 (98)	10,754 (97)	
Unknown	93 (1.2)	197 (1.8)	
N/A	17 (0.2)	46 (0.4)	
A1 fracture	4,317 (53)	2,315 (20)	0.74
Short/long IMN		2,114/201	
A2 fracture	3,822 (47)	9,481 (80)	
Short/long IMN		7,813/1,668	

Standardized mean difference (SMD) < 0.25 implicates no difference between groups.

^a Distribution of injury type (%) in patients with existing registration of injury type. Missing data on injury type for 395 SHS- and 712 IMN-patients.

A1 fracture = 2-fragment trochanteric fracture;

A2 fracture = multifragmentary trochanteric fracture.

A sensitivity analysis with the IMN group divided into patients operated on with a short and a long IMN indicated that use of long IMN conferred an increased adjusted risk of death within 30 days (RR 1.2, CI 1.1–1.5) when compared with patients treated with SHS, while a smaller increase was found after the use of short IMN (RR 1.1, CI 1.0–1.2). Point estimates of the RR for 30-day mortality were consistent when analyzing A1 and A2 fractures separately, with RR 1.1 (CI 0.9–1.3) and 1.1 (CI 1.0–1.3), respectively, for IMN compared with SHS.

Adjustment for comorbidity

A sensitivity analysis on the subgroup of patients on whom information on comorbidity was present indicated similar distributions of CCI between treatment groups; with 52% versus 52% in CCI 0, 34% versus 33% in CCI 1–2, and 15% versus 15% in CCI ≥ 3, for IMN and SHS respectively. The multivariable regression analysis for this smaller cohort with adjustment also for CCI indicated an increased adjusted risk of death at 7 days; RR 1.6 (1.0–2.5), and at 30 days for IMN; RR 1.1 (0.9–1.4).

Discussion

We found a slightly increased risk of death within 30 days for patients treated with IMN after sustaining a THF when compared with those operated on with an SHS. Our study includes a large sample, which enables us to detect differences in mor-

Table 2. Crude mortality (%) divided by treatment method: sliding hip screws (SHS) or intramedullary nail (IMN)

Mortality	SHS n = 8,139	All IMN n = 11,796	Short IMN n = 9,927	Long IMN n = 1,869	All n = 19,935
7-day	2.2	2.7	2.6	3.2	2.5
30-day	7.8	8.8	8.6	9.5	8.4
90-day	15	16	15	17	15
365-day	27	27	27	28	27

Table 3. Relative risk (RR) of death (95% CI) at 7, 30, 90, and 365 days depending on treatment in 19,935 patients with trochanteric hip fractures treated with either intramedullary nails (IMN) or sliding hip screws (SHS: reference group), adjusted for fracture type, age, and sex

Type	RR 7-day	RR 30-day	RR 90-day	RR 365-day
SHS	Ref.	Ref.	Ref.	Ref.
IMN	1.2 (1.0–1.5)	1.1 (1.0–1.2)	1.0 (1.0–1.1)	1.0 (1.0–1.1)

tality that might escape notice in regular-sized randomized controlled trials (5).

A UK study on > 80,000 patients above 60 years of age with THF (6) reported a 13% increase in 30-day mortality for IMNs compared to SHSs, which is in concordance with our findings. Our populations were similar regarding age and sex distribution but differed regarding a much larger share of SHS and a predominance of long over short IMNs in the UK study. Albeit smaller, we believe our study to bring new knowledge as we provide data on the different subtypes of fractures which was not accessible in the UK study and was thereby not adjusted or stratified for.

Our study design cannot determine causality, in particular not any underlying cause of increased short-term mortality in patients treated with IMN. Both treatment methods stabilize the THF, but only with intramedullary nailing is there a disturbance of the femoral canal, which may lead to increased pressure and fat intravasation with embolic outbursts (13,14). These events could exceed the physiological limits for these fragile patients and thus be a contributing factor to death. Our findings of an even more increased mortality risk associated with long nails than short compared with SHS supports this mechanism. When nailing THFs, reaming is usually not performed, indicating that even the introduction of an IMN is potentially dangerous to the vulnerable patient. This is supported by a cadaveric study on human bones showing no difference in intramedullary pressure increase whether reaming or not prior to IMN (15). Also, maximum fat embolization is seen at IMN introduction independent of intramedullary pressure (14), which could explain that patients with THF who often have rather osteopenic proximal femora with wide femoral canals may also experience fat emboli even in the absence of reaming.

Reports in the literature of increased blood loss when using SHS might influence surgeons to use IMN in patients on anti-coagulation or for other high-risk patients (16–18). However, we found a similar CCI distribution in both treatment groups.

Mortality vs. sex, function, and comorbidity

Increased age, male sex, and increased ASA grade have all been associated with increased mortality after trochanteric fractures (19,20), which is in accordance with the increased crude mortality rates in males and older patients in our cohort (data not shown). These patients are extremely vulnerable in the early postoperative period and continuously over the first year with only slightly decreasing elevated adjusted risk of death following THF. In the study by Tucker et al. (7) on unstable A2 and A3 fractures, IMN was used more often in patients with better preoperative function, but ASA distribution was equal between treatment groups. The subgroup analyses on patients with CCI showed similar distribution of CCI between treatment groups and a risk of death of the same magnitude after IMN as in the large cohort. We did not have control over subgroups of A2 fractures because these subgroups have been added to the SFR only recently.

Treatment choice

Based on Scandinavian tradition, the use of IMNs in stable trochanteric fractures is higher compared with the UK (4,6,21). The use of IMN nails varies from 0% to 90% for stable THF at Swedish hospitals (9). This reflects the lack of national guidelines in Sweden regarding the treatment of THF. That national preferences are guiding the choice is illustrated by the US guidelines recommending both SHS and IMN for stable THF (A1) and favoring the use of IMN to treat unstable trochanteric fractures (A2 and subtrochanteric A3) (22). In contrast, the NICE guidelines in the UK state that SHS should be used rather than IMN for A1 and A2 THF fractures (23).

Fracture classification does affect surgeons in choosing implant type, although surgical training and country of residence also matters (1). In our study 1 in 3 patients with stable A1 fractures received an IMN compared with 7 in 10 in the more unstable A2 group, although there is no evidence for the superiority of IMNs in these fractures (23), nor are IMNs cost-effective (3). In the UK the majority of patients were operated on using an SHS (6), adhering to the NICE guidelines (23). The increased use of IMN at the expense of SHS is well documented (24–26). This variation of practice, despite the absence of compelling evidence indicating superiority of either implant in treatment of AO/OTA A1 and A2 fractures, is difficult to explain (16,17,27–31).

Disagreement in classification of THF is low (32) and cannot explain the observed trend for more IMNs. Potential theoretical biomechanical advantages, reimbursement practices, and industry marketing favoring IMN can be additional factors increasing IMN use (24).

Strengths and limitations

We used the SFR to retrieve information on a large group of patients with trochanteric fractures with classification of the fractures in 2-fragment A1 and multifragmentary A2 fractures. A previous validation study showed substantial agreement for classification regarding AO/OTA group according to Landis and Koch (24). There were no missing data regarding age, sex, fracture type, or treatment in this cohort. Another strength of the study is high-quality data on mortality, due to exact matching of personal identity number from the SFR and all administrative registers, in this case the Swedish Tax Agency, which delivers dates of death for all patients in the SFR. As long as a person is deceased anywhere within the borders of Sweden, the outcome is included in our study. Trochanteric fractures are of course more diverse than indicated by the coarse classification into A1 and A2, and a more detailed classification as recently proposed by the AO/OTA (33) could potentially give more information on why the actual type of treatment method was used. In addition, we cannot rule out confounding by indication, e.g., that frailer patients may have received long IMN to protect them better from future peri-implant fractures, or individuals with more complex fractures were prone to be operated on with long IMN. The SFR does not contain comorbidity indices, but a Swedish register analysis has shown age and sex to be more accurate than Elixhauser and CCI to predict death (34). A smaller subgroup within our study cohort had previously been crossmatched with the NPR, giving us CCI for that subgroup of patients and enabling us to perform a sensitivity analysis including adjustment for comorbidity. Taken together, this sensitivity analysis resulted in an enhanced estimate for the adjusted risk of death within 7 days, and a similar adjusted risk of death within 30 days.

Conclusion

This observational study indicates that the use of IMN for the treatment of AO 31-A1 or -A2 THF seems associated with a slightly increased risk of death within 30 days. Since there is little scientific evidence to support the use of IMN in these fracture types the current trend for using IMN rather than SHS may not be justified.

OW, SM, and NPH planned the study. OW wrote the initial draft. JE performed the analyses. All authors contributed to the interpretation of the data and revision of the manuscript.

Acta thanks Anne Marie Fenstad and Jan-Erik Gjertsen for help with peer review of this study.

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