CLINICAL PRACTICE

Treatment of Intertrochanteric Femur Fractures with Long versus Short Cephalomedullary Nails

Cameron Sadeghi, MD[1]; Heather A. Prentice, PhD[2]; Kanu M. Okike, MD[3]; Elizabeth W. Paxton, PhD[2]

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ABSTRACT

Context: Prior studies regarding indications for long vs short cephalomedullary nails in the treatment of intertrochanteric fractures had limited sample sizes and follow-up, suggesting a need for further investigation.

Objective: To evaluate the association between cephalomedullary nail length and outcomes for the treatment of intertrochanteric femur fractures.

Design: Cohort study using Kaiser Permanente's Hip Fracture Registry. A total of 5526 patients who underwent surgical treatment with cephalomedullary nails for an intertrochanteric femur fracture (2009-2014) were identified: 3108 (56.2%) with long nails and 2418 (43.8%) with short nails. Cox proportional hazards model regression was used to evaluate risks of all-cause revision and revision for periprosthetic fracture. Linear regression was used to evaluate operative time, estimated blood loss, and length of stay. Propensity score weights were used in all models to balance nail groups on patient and device characteristics.

Main Outcome Measures: All-cause revision surgery.

Results: No association was found in risk of all-cause revision (hazard ratio = 0.75, 95% confidence interval [CI] = 0.48-1.15) or revision for periprosthetic fracture (hazard ratio = 0.59, 95% CI = 0.23-1.48) for long nails compared with short nails. Use of longer nails resulted in 18.80 more minutes of operative time (95% CI = 17.33-20.27 minutes), 41.10 mL more of estimated blood loss (95% CI = 31.71-50.48 mL), and a longer hospitalization (8.4 hours; β = 0.35, 95% CI = 0.12-0.58 hours).

Conclusion: These findings suggest that routine use of short cephalomedullary nails is safe and effective in the treatment of intertrochanteric fractures.

INTRODUCTION

Cephalomedullary nails are the most common fixation device used in the treatment of intertrochanteric femur fractures.[1] Cephalomedullary nails are commonly divided into long and short devices. Little consensus exists regarding indications for long vs short nails in the treatment of intertrochanteric fractures. Early designs of short cephalomedullary nails were associated with a higher risk of periprosthetic fracture, but with the newer generation of nails, this risk was reduced.[2]

Experts have recommended long nails for unstable and highly displaced fracture patterns because of the perceived protective effect of long nails in preventing refracture in this population of patients, who commonly have osteoporotic bones and a higher risk of falls.[3] Historically, long nails were recommended to reduce the risk of future periprosthetic femur fractures. Results of prior studies have failed to identify differences in failure or periprosthetic fracture rates between long and short nails, but they demonstrated a reduced surgical time and blood loss for short nails.[4-9] However, these studies have been limited by small sample sizes and short postoperative follow-up, suggesting a need for further investigation.

Using data from a US hip fracture registry (HFR), we sought to investigate the following questions: 1) Is there a difference in revision risk, either all-cause or for periprosthetic fracture, when using long vs short cephalomedullary nails in the treatment of intertrochanteric femur fractures? 2) Does operative time, estimated blood loss, or inhospital length of stay (LOS) differ for patients who receive a long vs short cephalomedullary nail in the treatment of intertrochanteric femur fractures?

METHODS

Study Design, Setting, and Sample

We conducted a retrospective cohort study using data from an integrated health care system's HFR, the Kaiser Permanente Hip Fracture Registry. Kaiser Permanente covers more than 12.2 million members throughout 8 US geographical regions (ie, Colorado, Georgia, Hawaii, Mid-Atlantic, Northern California, Northwest, Southern California, and Washington). Members of the integrated health care system have been previously shown to be representative of the regional population served,[10,11] increasing generalizability of study results.

The study sample was selected using the HFR and consisted of patients with a closed femur-based fracture of the intertrochanteric section who underwent primary fixation procedures from 2009 through 2014. Intertrochanteric fractures were identified using International Classification of Diseases, Ninth Revision (ICD-9) code 820.21 and adjudicated through implant information. Only fractures fixed with the 2 highest volume implants in the HFR, the Gamma3 Nailing System (Stryker Orthopaedics, Kalamazoo, MI) and the trochanteric femoral nail (TFN, DePuy Synthes, West Chester, PA), were included. The study consisted of 5526 hip fracture procedures: 3108 (56.2%) with long nails and 2418 (43.8%) with short nails.

Author Affiliations
[1] Department of Orthopaedic Surgery, Southern California Permanente Medical Group, San Diego, CA, USA
[2] Surgical Outcomes and Analysis, Kaiser Permanente, San Diego, California, USA
[3] Department of Orthopaedic Surgery, Kaiser Moanalua Medical Center, Honolulu, HI, USA

Corresponding Author
Cameron Sadeghi, MD (Cameron.X.Sadeghi@kp.org)

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Data Source

A detailed summary of data collection procedures for our HFR has been previously described.[12] Started in 2009, this surveillance tool for all surgically treated hip fractures performed in 4 regions of our health care system (Hawaii, Northern California, Northwest, and Southern California) captures patient, procedure, implant, surgeon, and hospital information using the electronic health record (EHR), administrative claims data, health care membership data, other institutional databases, and mortality records. From 2009 to 2014, the registry included 26,873 procedures. Coverage is 100% for all surgically treated hip fractures performed in Kaiser Permanente. Outcomes are longitudinally monitored after the index procedure using electronic screening algorithms and are validated by trained clinical content experts using the EHR.

Treatment

The treatment of interest was length of the cephalomedullary nail. For this study, long nails were defined as those extending into the distal metadiaphysis and short nails as 170 to 180 mm in length. Nails that were not classified as long or short according to these definitions were excluded from the analysis. Data for all implants (including nails) were entered into the EHR at the time of implantation via a barcode scan. This detailed implant information is extracted from the EHR to the registry and is reviewed by clinical content experts, who classify each implant into its respective category.

Outcome

The primary outcome of interest was all-cause revision surgery. Revision was defined as any reoperation performed after the index procedure where an implant was exchanged. Secondary endpoints included revision for periprosthetic fracture, operative time (in minutes), estimated blood loss (in milliliters), and in hospital LOS (in days). Revision outcomes were time-to-event with follow-up time defined as the time from the index procedure date until the date of revision surgery, health care membership termination, death, or study end date (December 31, 2014), whichever came first. Date of membership termination and death for survival endpoints were treated as censored cases, with survival time based on the time those cases exited the study sample.

Statistical Analysis

Several potential confounders of treatment were considered, including age, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, sex, race/ethnicity, and use of interlocking screws. Average treatment effects were estimated by incorporating inverse probability of treatment weights in a Cox proportional hazards regression for survival endpoints (revision surgery) and a linear regression model for continuous endpoints (operative time, estimated blood loss, LOS). The use of weights can induce dependence in the data, and an effective option for variance estimation is a nonparametric bootstrap.[13] Given the presence of missing data on some covariates, for each bootstrap sample a single imputation (imputation model included all potential confounders, outcomes,[14] and treatment) was performed[15] under a fully conditional specification.[16] Subsequently, inverse probability of treatment weights were calculated (ie, using a logistic regression model with the listed confounders as predictors of treatment assignment and a caliper restriction of 0.20 standard deviation [SD] of the logit propensity score[17,18]), and a treatment effect was estimated.

We used 500 bootstrap samples to calculate the treatment effect estimate (mean of the samples) and the variance of the estimate. Hazard ratios (HRs) for survival endpoints, β estimates for continuous endpoints, 95% normal-theory confidence intervals (CIs), and 2-sided p-values were reported. Analyses were performed using R version 3.3.0 software, and $\alpha = 0.05$ was the statistical significance threshold used for this study.

RESULTS

Among the 5526 hip fracture procedures, there were 96 all-cause revisions (1.7%). Of the 96 revisions, 50 (1.6%) were among the 3108 cases using long nails and 46 (1.9%) were among the 2418 with short nails. Twenty-seven (0.5%) revisions were for periprosthetic fracture specifically: 13 (0.4%) among long nails and 14 (0.6%) among short nails. Operative times, estimated blood loss, and LOS data were available from 5493 (99.4%), 4696 (85.0%), and 5504 (99.6%) of the 5526 hip fractures, respectively. Mean (SD) operative time, estimated blood loss, and LOS for long vs short nail groups were as follows: 62.7 minutes (SD = 33.1) vs 47.4 minutes (SD = 22.8 minutes), 135.7 mL (SD = 151.7 mL) vs 99.8 mL (SD = 105.5 mL), and 5.57 days (SD = 4.43 days) vs 5.34 days (SD = 4.24 days).

Member terminations during the follow-up period included 201 patients (3.6%), and there were 2027 deaths (36.7%).

Cephalomedullary Nail Length and Revision Risk

Unadjusted cumulative incidence curves for time to all-cause revision stratified by nail length are displayed in Figure 1. Propensity score weights significantly reduced the imbalance of the devices on the covariates (all standardized differences < 0.01; Table 1). After the application of inverse probability of treatment weights, we failed to observe evidence of a difference in risk of all-cause revision when long nails were compared with short nails (HR = 0.75, 95% CI = 0.48-1.15, p = 0.186). A subgroup analysis based on conditional (regression-adjusted) proportional hazards models indicated a lack of evidence supporting a difference between Gamma3 and TFN (reference group) among long nails (HR = 1.13, 95% CI = 0.63-2.04, p = 0.675) and short nails (HR = 0.79, 95% CI = 0.39-1.61, p = 0.521), with respect to all-cause revision. The use of interlocking screws was not associated with a higher risk among long nails (HR = 0.90, 95% CI = 0.51-1.58, p = 0.703) or short nails (HR = 0.78, 95% CI = 0.35-1.76, p = 0.554; reference group = no interlocking screw). The primary reason for all-cause revision was fixation failure/symptomatic implant for both long and short nails, 56.0% and 52.2%, respectively (Table 2). A similar conclusion was reached when we looked specifically at risk of revision for periprosthetic fracture for long vs short nails (HR = 0.59, 95% CI = 0.23-1.48, p = 0.258).

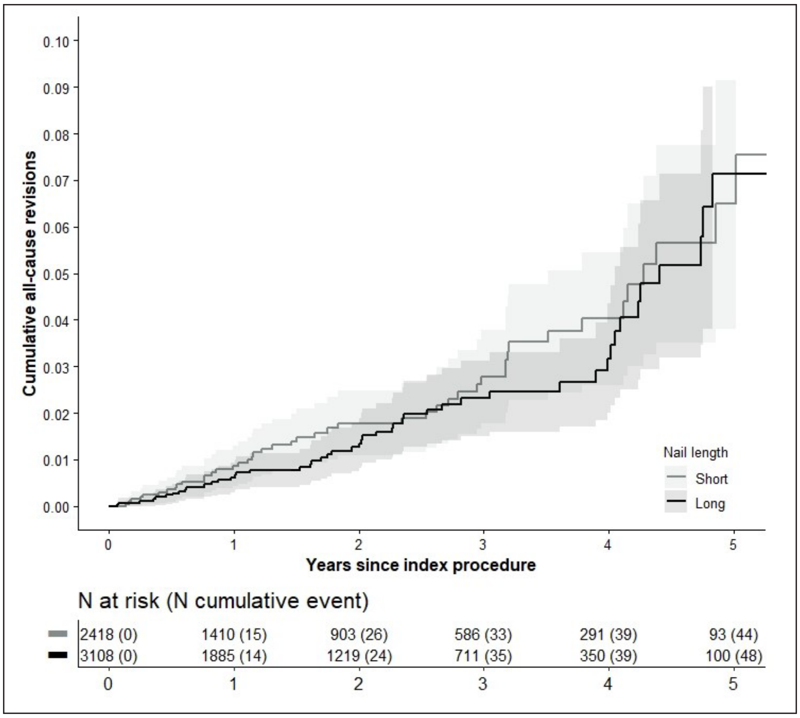

Figure 1. Cumulative incidence of all-cause revision for long (black line) and short (gray line) cephalomedullary nails after surgical repair of intertrochanteric hip fracture.

Table 1. Descriptive statistics and covariate balance for 5526 patients undergoing intertrochanteric hip fracture surgery using a cephalomedullary nail, by nail length (2009-2014)

Characteristic[a]	Long nail (n = 3108)	Short nail (n = 2418)	Preweight standardized difference	Postweight standardized difference
Continuous, mean (SD)				
Age, y	80.6 (11.0)	81.2 (10.8)	0.06	0
BMI, kg/m2	24.6 (5.4)	24.1 (5.1)	0.11	0.01
ASA classification	2.8 (0.6)	2.9 (0.6)	0.10	0
Categorical, no. (%)				
Female sex	2170 (69.8)	1698 (70.3)	0.01	0
Race/ethnicity Asian	141 (4.5)	225 (9.3)	0.18	0
Hispanic	367 (11.9)	202 (8.4)	0.11	0.01
White	2465 (79.6)	1870 (77.7)	0.04	0.01
Other	124 (4.0)	111 (4.6)	0.02	0
Interlocking screws	1937 (62.3)	2109 (87.2)	0.61	0.01

[a] Missing data: BMI (n = 29), ASA (n = 74), sex (n = 1), race/ethnicity (n = 21).

ASA = American Society of Anesthesiologists; BMI = body mass index; preweight = before applying propensity score weights; postweight = after applying propensity score weights; SD = standard deviation.

Table 2. Reasons for revision by cephalomedullary nail length[a]

Reason	Long nails (n = 50)	Short nails (n = 46)
Fixation failure/symptomatic implant	28 (56.0)	24 (52.2)
Infection	0 (0)	1 (2.2)
Osteonecrosis	1 (2.0)	2 (4.4)
Posttraumatic osteoarthritis	2 (4.0)	5 (10.9)
Periprosthetic fracture	13 (26.0)	14 (30.4)
Malunion	1 (2.0)	1 (2.2)
Nonunion	11 (22.0)	6 (13.0)

a Patients could have more than 1 revision reason. Data are number (%).

Table 3. Risk of outcomes for long versus short cephalomedullary nails in linear regression models fit with inverse probability of treatment weights

Outcome	β (95% CI)	p value
Operative time,[a] min	18.80 (17.33-20.27)	< 0.001
Estimated blood loss,[b] mL	41.10 (31.71-50.48)	< 0.001
Inhospital length of stay,[c] d	0.35 (0.12-0.58)	0.003

a n = 5493.
b n = 4696.
c n = 5504.
CI = confidence interval.

Secondary Outcomes

In adjusted models, long nails were associated with 18.80 more minutes of operative time (95% CI = 17.33-20.27 minutes, $p < 0.001$; Table 3). There was 41.1 mL more of estimated blood loss for long nails compared with short nails (95% CI = 31.71-50.48 mL, $p < 0.001$), and patients who received a long nail had a longer inhospital LOS (8.4 hours; $\beta = 0.35$, 95% CI = 0.12-0.58 hours, $p = 0.003$).

DISCUSSION

Cephalomedullary nails are the most common method for stabilizing intertrochanteric femur fractures, but controversy exists regarding the indications for long vs short nails. Several studies have compared the use of long and short nails, but many of these have been limited by sample size and length of follow-up. Therefore, we evaluated the risk of all-cause revision for a large cohort of patients treated with long vs short cephalomedullary nails using the Kaiser Permanente Hip Fracture Registry. Even in our cohort of more than 5500 patients, we failed to observe a difference between nail length and risk of revision, but long nails did have a longer operative time, a greater estimated blood loss, and a longer LOS.

In general, we found high union rates and a low incidence of implant revision for intertrochanteric femur fractures with cephalomedullary nails: 1.9% for all-cause revision and 0.5% for revision due to periprosthetic fracture specifically. This is in line with results of recent studies that have reported the risk of ipsilateral femur refracture in the range of 0.5% to 10%.[4-6,8,19,20] In a larger study sample, after adjusting for a number of potential confounders, our revision findings are consistent with results of prior studies with smaller sample sizes investigating long vs short nails.[5,8,9,21-23] Most of these prior studies had sample sizes of around 200 patients, with the exception of the study by Liu et al,[9] which included 899 patients. There has been concern reported regarding heterogeneity across implant devices.[5] However, our results held even when stratifying the data by patients treated with Gamma3 vs TFN nails. The most common reason for revision surgery, regardless of nail length, was the presence of symptomatic implants. The registry lacked detail on whether this was due to a cut-out or removal of a painful implant, and this is a study limitation.

Our findings on operative time and estimated blood loss are similar to those of a prior report.[5] Our LOS findings are similar to those of a prior study[21] but contrast with another study that reported no difference in LOS.[5] One reason for this discrepancy might be a longer procedure time for localizing and placing a distal interlocking screw in long nails. Furthermore, our analysis accounted for a number of patient and surgical factors through propensity score weighting before the evaluation of outcomes.

Although our findings for operative time, estimated blood loss, and LOS are statistically significant, we acknowledge that the differences observed in these outcomes by nail length may be of limited clinical significance. An increase in LOS by 8 hours for patients treated with long nails may be related to an inherent selection bias in which patients with more severe fracture patterns are more likely to be treated with a long nail. Higher rates of transfusion related to more blood loss have also been previously reported in prior studies, which could also prolong LOS.[5,21] Our registry lacks detail on transfusions; therefore, this could not be investigated in the present study.

Our study is not without limitations. This study is observational in nature, and causation cannot be inferred. To mitigate confounding due to differences across implant designs outside of nail length, we restricted the study sample to the 2 highest volume designs in the HFR. Furthermore, although we attempted to account for potential confounders in our analysis, residual confounding due to unmeasured variables is a possibility. For example, we were unable to account for fracture type and surgeon decision making. A surgeon may judge a fracture, such as those with large posteromedial fragments or subtrochanteric extension, to be more unstable, and preferentially select a long cephalomedullary nail in the treatment of these fractures. We also were unable to perform radiographic review for the entire study sample but relied instead on diagnostic coding to identify patients with intertrochanteric fractures. However, we do not expect diagnosis coding of intertrochanteric fractures to depend on receipt of a long or short nail.

Study strengths include use of our institution's hip fracture registry as the data source, which prospectively collects information on a predefined set of variables. Outcomes are longitudinally tracked using algorithms and are validated through manual chart review, which increases the internal validity of our study.

CONCLUSION

In a cohort of more than 5500 patients with intertrochanteric fractures who underwent hip fracture surgery using a cephalomedullary nail, we failed to observe a difference in risk of all-cause revision and revision for periprosthetic fracture regardless of use of long or short nails. Short cephalomedullary nails resulted in shorter operative times, with a lower estimated blood loss, and a shorter LOS. These findings suggest that a surgeon's routine use of short cephalomedullary nails may be appropriate in the treatment of intertrochanteric fractures.❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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