Variation In Revisions After Proximal Femoral Fracture Fixation—Low Surgeon Volume is Associated with Higher Revision Rates

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Highlights

- Higher surgeon volume of proximal femoral fracture (PFF) surgery was associated with lower revision rates and mechanical complications, as well as reductions in readmissions, malunion, and nonunion.
- Surgeon volume was a more consistent predictor of outcomes after PFF surgery than hospital characteristics, e.g., teaching status and PFF volume.
- Regardless of hospital volume and teaching status, surgeon PFF volume varies, leading to differences in the risk of adverse outcome.
- Digital technologies could offer consistency and accuracy of intramedullary nailing (IMN) implantation to reduce risk of revision surgery.

Introduction

PFF is a common injury in the elderly population. Intramedullary nailing (IMN) remains a commonly used treatment, especially in displaced fractures.

Surgical procedural factors, such as tip-apex distance (TAD) have been empirically shown to be associated with post-operative complications.

Surgical expertise, hospital volume, and teaching status impact outcomes and the incidence of complications associated with PFF fixation, but evidence of association with surgeon-level characteristics is lacking.

Objectives

We examined variations in the rate of adverse outcomes (revisions, readmissions, complications) after PFF fixation and their association with surgeon- and hospital-level characteristics, with risk adjustment for a comprehensive list of patient clinical characteristics.

Data

Data were extracted retrospectively using the 100% Fee-for-Service (FFS) Medicare Limited Data Set (LDS) Standard Analytic Files (SAF).

Table 1. Post-operative outcomes at 30-day, 90-day, and 1-year post-index

Outcomes	30-Day	90-Day	1-Year
N	295,733[a]	265,215[a]	193,959[a]
	%	%	%
Revision	0.8	2.1	5.9
Total hip arthroplasty[b]	0.3	1.0	2.7
Hip-related readmission	2.0	3.4	6.3
Mechanical complication	1.1	2.0	3.5
Malunion	-	-	0.5
Nonunion	-	-	1.4
Any outcome above	-	-	10.4

[a]Analysis is limited to patients continuous enrolled in Medicare FFS through the follow-up time window.
[b]Total hip arthroplasty is a subset of revision.

Table 2. Predicted revision rates based on the surgeon's annual volume

Outcome	30-Day Revision*			90-Day Revision*			1-Year Revision*		
	N=295,733[a]			N=265,215[a]			N=193,959[a]		
Surgeon annual volume	Pred Revision Rate, %	Marginal Diff, %	95% CI	Pred Revision Rate, %	Marginal Diff, %	95% CI	Pred Revision Rate, %	Marginal Diff, %	95% CI
<5	0.84	Ref	Ref	2.27	Ref	Ref	6.07	Ref	Ref
5-9	0.78	-0.06	(-0.16, 0.000)	2.19	-0.08	(-0.24, 0.09)	6.00	-0.07	(-0.39, 0.24)
10-18	0.74	-0.10	(-0.20, 0.000)	2.15	-0.12	(-0.28, 0.04)	5.92	-0.15	(-0.46, 0.16)
19+	0.65	-0.19	(-0.28, -0.001)	1.96	-0.31	(-0.48, -0.14)	5.57	-0.50	(-0.82, -0.19)

[a]Analysis is limited to patients continuously enrolled in Medicare FFS through the follow-up time window.
*Revision is measured for the time window aligned with the total payment, i.e., revision is measured within 30 days for a 30-day total payment.

Results

We identified 523,658 patients who underwent PFF surgery between January 2016 and December 2023. Of these, 342,030 were patients whose surgery used IMN.

The majority of patients were Caucasian (92.2%), 75+ years of age (78.8%), and females (71.0%). Most patients had fractures of the trochanteric location (85.3%), followed by head and neck (15.4%), subtrochanteric (9.4%) and basicervical (0.8%). Note that patients could have fractures at one or more of abovementioned locations. Most fractures were displaced and closed (85.0% and 94.9%, respectively).

Nearly 80K (23%) of patients were treated by surgeons with an annual volume of < 5 procedures and 250K (73%) with surgeons with an annual volume of < 19 procedures. Over half of the patients (55.3%) were treated in a teaching hospital. 22.7% of patients were treated in hospitals with fewer than 33 PFF surgeries; 27.3% of patients were treated at hospitals with the highest annual volumes (> 95 procedures).

The revision rate was 0.8% at 30-day post index surgery, increasing to 2.1% by 90-day and 5.9% at 1-year post-index. At 1-year post index, THA accounted for 45.7% of revisions. At 1-year, 10.4% of patients experienced at least one adverse event. **(Table 1)**

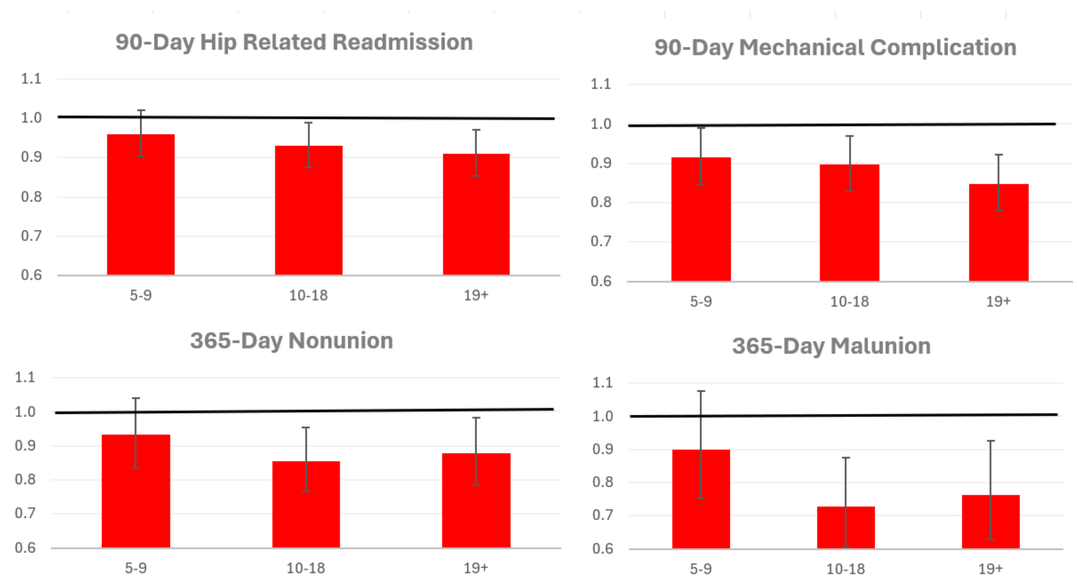
Methods

We included patients aged ≥65 years with an ICD-10-PCS or CPT code indicating initial encounters of PFF with IMN (index surgery) from Jan 1, 2016, to Dec 31, 2023. Continuous Medicare Part A/B enrollment was required from 6-months before index surgery through the end of each follow-up window.

The primary outcome was revision (including revision, reinsertion, reposition, replacement of internal devices and any total hip arthroplasty) following index surgery, at 30-day, 90-day (both short-term), and 1-year (longer-term). Additional outcomes included hip-related hospital readmissions, mechanical complications (e.g., displacement, dislocation, breakdown, periprosthetic fracture, wear of articular bearing surface or mechanical loosening of internal devices), malunion, and nonunion.

Generalized Linear Models with logit link and binomial distribution were used to assess the relationship between provider characteristics and outcomes, adjusted for patient demographics, clinical characteristics, fracture location and type. We then used recycled prediction to estimate the incremental revision risk by surgeon volume. Surgeon annual volume of PFF surgery was categorized into quartiles: <5, 5-9, 10-18 and 19+.

Figure 1. Association between surgeon volume and adverse outcomes



Note: Odds ratio and 95% confidence intervals are generated from the generalized linear models predicting revision during each post-index follow-up period, with risk adjustment. Surgeon volume represents the annual number of cases of proximal femur fractures and is classified into four categories: <5 (reference), 5–9, 10–18, and 19+. Values < 1 suggest lower odds ratios.

Higher surgeon annual volume of PFF surgery was consistently associated with a lower risk of revision. Compared to being treated by surgeons with an annual volume of less than 5 procedures, revision risk was 0.19% lower at 30-day (23% reduction), 0.31% lower at 90-day (14% reduction) and 0.50% lower at 1-year (8% reduction) (**Table 2**).

Furthermore, surgeon volume, specifically the contrast between 19+ annual procedures vs. <5 procedures, tended to be associated with lower rates of other adverse outcomes, including hip-related readmission, mechanical complications, malunion, and nonunion (**Figure 1**).

Discussion

Lower surgeon volume was associated with higher rates of adverse outcomes after PFF surgery with intramedullary nailing.

Although not consistently statistically significant, hospital volume of PFF surgery and teaching status showed an association with a lower revision rate. This is possibly due to variations in surgeon volume, regardless of hospital teaching status.

These findings present an opportunity for emerging digital technologies, which have been shown to reduce variation in tip-apex distance and therefore lower opportunity for screw cut-out, to provide consistency and accuracy of IMN implantation, potentially improving patient outcomes.