Revisions After Proximal Femoral Fracture Fixation—Economic Burdens and Association with Provider Characteristics

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INTRODUCTION: Proximal femoral fracture (PFF) represents >5% of all adult fractures. Despite overall success and effectiveness of PFF fixation, complications are common, and the required reoperations are associated with increased healthcare costs and patient morbidity. We examined the rate of adverse outcomes, provider characteristics associated with higher rates, and mortality and the economic burden associated with revisions after proximal PFF fixation.

METHODS: Patients aged 65+ years with procedure and diagnosis codes indicating PFF treated with an intramedullary nail (IMN) (index surgery) were identified in the 100% Fee-for-Service Medicare Standard Analytic Files (SAF) from 1/1/2016 to 12/31/2023. Continuous Medicare Part A/B enrollment was required from 6-months before index surgery through each follow-up window up to a year post the index surgery.
The primary outcome was revision after index surgery within 365-days post-index. Additional outcomes included mechanical complications and hip-related readmission, malunion, and nonunion. All outcomes were analyzed at 30-, 60-, 90- and 365-days to test the robustness of results. The interpretation focuses on all time windows for revision, 90-days for complications and readmissions and 365-days for malunion and nonunion as these time windows were more aligned with clinical practice for specific outcomes. We also measured Medicare payment (proxy of resource utilization) including index surgery and through 365 days post-index surgery, and 1-year mortality.
Generalized Linear Models (GLM) with log link and binomial distribution were used to assess the relationship between provider characteristics (surgeon and hospital annual volume of PFF surgery, teaching status, rural/urban, and region) and outcomes, adjusted for patient demographics, clinical characteristics, fracture location and type. We used GLM with log link and Gamma distribution to assess the relationship between revisions and total payment. We then used recycled prediction to estimate the incremental total payment associated with revisions.

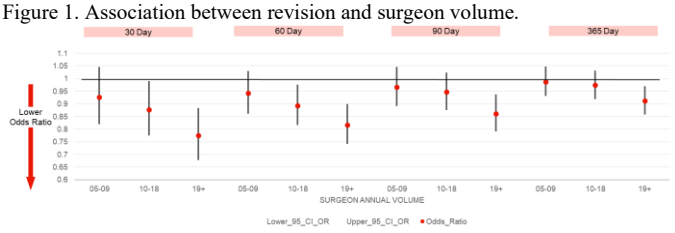
RESULTS SECTION: We identified 523,658 patients who underwent PFF surgery, two thirds of whom had an intramedullary internal fixation device (IMN). Nonexclusive fracture locations included trochanteric (85%), head and neck (15%), subtrochanteric (9%) and basicervical (1%). Across fracture location, pathologic fracture was indicated for 9% of patients. 85% of patients had displaced fractures and 95% had closed fractures.
About half of the patients were treated in a teaching hospital. Compared to non-teaching hospitals, teaching hospitals had higher mean annual PFF surgery volume (90 vs. 52) and higher annual average surgeon volume (16 vs.12). The majority of cases were treated in an urban hospital.
Revision rate was 0.8% at 30-days, 1.6% at 60-days, 2.1% at 90-days and 5.9% at 365-days. Total hip arthroplasty accounted for 45.7% of revisions at 365-days. The rates for other outcomes were: 2.0% and 3.5% for mechanical complications, and 3.4% and 6.3% for hip-related rehospitalizations at 90-days and 365-days, respectively; 0.5% and 1.4% for malunion and nonunion at 365-days, respectively.

Higher surgeon annual volume of PFF surgery had the most consistent association with lower rates of revision (Figure 1). Odds ratio of revision for high volume surgeons (annual volume 19+) vs. low volume surgeons (<5 annual cases) across 30-day, 60-day, 90-day and 365-day follow-up windows were: 0.77 (0.68-0.88), 0.82 (0.74-0.90), 0.86 (0.79-0.93), 0.91 (0.86-0.97). Additionally, surgeon volume tended to be associated with lower rates of other adverse outcomes, including mechanical complication, hip related readmission, malunion and nonunion, especially for the annual volume of 19+ group (Figure 2). Teaching status showed a tendency of association with lower revision rate, but was not consistent across follow-up windows, possibly due to variation of surgeon volume regardless of hospital teaching status. For patients requiring revision, the incremental total payment at 30-, 90-, and 365-days post-index were $17,219 (95% CI: $16,423 - $18,014), $28,355 (95% CI: $26,982 - $29,728), and $33,324 (95% CI: $30,751 - $35,897), respectively. Among patients with 90-day survival, patients with a revision within 90 days had about 5% higher 1-year mortality than patients without revision (19.8% vs. 14.9%).

DISCUSSION: Using a large national sample with risk adjustment of patient clinical and fracture characteristics, we found that higher surgeon volume had the most consistent association with lower revision and other adverse outcomes after PFF surgery with IMN. Revision was associated with elevated 1-year mortality and incremental total payment. In our study, 23% of patients were treated by surgeons with annual volume < 5 and 73% with surgeons with annual volume < 19.

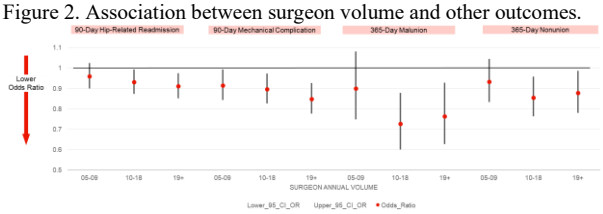
SIGNIFICANCE/CLINICAL RELEVANCE: Our findings present an important opportunity for emerging digital technologies to level set consistency and accuracy of IMN implantation, potentially improving patient outcomes and reducing the considerable costs and burdens associated with revisions for patient and healthcare systems.

Figure 1. Association between revision and surgeon volume.



Note: Odds ratio and 95% confidence intervals are generated from GLM model predicting revision during each post-index follow-up period, with risk adjustment. Surgeon volume represents annual cases of proximal femur fracture and is broken out into <5 (ref), 5-9, 10-18 and 19+. Estimates below 1 suggest lower odds ratios.

Figure 2. Association between surgeon volume and other outcomes.



Note: Odds ratio and 95% confidence intervals are generated from GLM model predicting revision during each post-index follow-up period, with risk adjustment. Outcomes presented including (from left to right): 90-day hip related readmission, 90-day mechanical complications, 365-day malunion and 365-day nonunion. Surgeon volume represents annual cases of proximal femur fracture and is broken out into <5 (ref), 5-9, 10-18 and 19+. Estimates below 1 suggest lower odds ratios.