



Does Implant Selection Affect the Inpatient Cost of Care for Geriatric Intertrochanteric Femur Fractures?

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Abstract

Introduction: Geriatric intertrochanteric (IT) femur fractures are a common and costly injury, expected to increase in incidence as the population ages. Understanding cost drivers will be essential for risk adjustments, and the surgeon's choice of implant may be an opportunity to reduce the overall cost of care. This study was purposed to identify the relationship between implant type and inpatient cost of care for isolated geriatric IT fractures. **Methods:** A retrospective review of IT fractures from 2013-2017 was performed at an academic level I trauma center. Construct type and AO/OTA fracture classifications were obtained radiographically, and patient variables were collected via the electronic medical record (EMR). The total cost of care was obtained via time-driven activity-based costing (TDABC). Multivariable linear regression and goodness-of-fit analyses were used to determine correlation between implant costs, inpatient cost of care, construct type, patient characteristics, and injury characteristics. **Results:** Implant costs ranged from \$765.17 to \$5,045.62, averaging \$2,699, and were highest among OTA 31-A3 fracture patterns ($p < 0.01$). Implant cost had a positive linear association with overall inpatient cost of care ($p < 0.01$), but remained highly variable ($r^2 = 0.16$). Total cost of care ranged from \$9,129.18 to \$64,210.70, averaging \$19,822, and patients receiving a sliding hip screw (SHS) had the lowest mean total cost of care at \$17,077, followed by short and long intramedullary nails (\$19,314 and \$21,372, respectively). When construct type and fracture pattern were compared to total cost, 31-A1 fracture pattern treated with SHS had significantly lower cost than 31-A2 and 31-A3 and less variation in cost. **Conclusion:** The cost of care for IT fractures is poorly understood and difficult to determine. With alternative payment models on the horizon, implant selection should be utilized as an opportunity to decrease costs and increase the value of care provided to patients.

Level of Evidence: Diagnostic Level IV.

Keywords

hip fracture, geriatric, intertrochanteric fracture, implant costs, inpatient cost of care

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Introduction

Geriatric intertrochanteric (IT) femur fractures are a common and costly injury, with an estimated annual incidence of 150,000, and costing \$6 billion USD each year.¹⁻³ The prevalence and cost of geriatric hip fractures are expected to increase drastically as the population ages.^{2,4} As such, geriatric hip fracture management is continuously targeted for improved quality and more coordinated care with the goal of reducing cost.^{3,5-7}

One effort to control costs and improve the value of orthopedic care has been the move in healthcare expenditure toward

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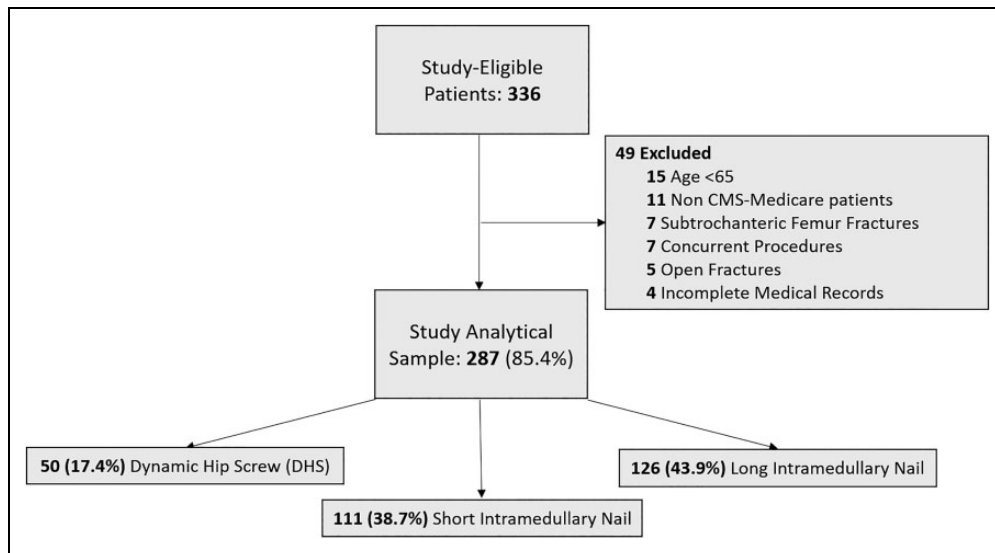


Figure 1. STROBE flow-chart for the study population visualizing patient inclusion and exclusions, between 2013-2018 (N = 287).

alternative payment models such as bundled payments, which provide a predetermined reimbursement based on a target price for a specific episode of care.⁸ Bundled payment programs such as Surgical Hip and Femur Fracture Treatment (SHFFT), which nearly became mandatory in 2018, are on the horizon for orthopedic trauma,^{7,9-11} and have already been implemented in other subspecialties—for example, the Comprehensive Care for Joint Replacement (CJR) is an alternative payment model that has successfully controlled cost and improved the value of orthopedic care in total joint replacement.^{8-10,12}

Given the impending shift to value-based care, it is imperative for orthopedic surgeons to evaluate their care to aid in the successful implementation of future bundled payment systems.^{13,14} However, bundled payment programs are difficult to implement for care of geriatric hip fractures because of the complexity and urgency of the procedure. As the procedure is not elective, patients cannot be optimized for surgery as outpatients, and tend to have multiple comorbidities that need to be optimized on an inpatient basis.¹⁵ The complexity and variability in treating IT fractures places risk on the hospital and physicians, for whom reimbursements will fall short of expenses if target prices are not sufficiently adjusted for risk.

With many factors outside providers' control, the choice of implant type is an ideal intervention for cost savings.^{8,11} Althausen and Mead, in describing their experience with implementation of bundled payment programs, highlighted the importance of implant costs as an opportunity for savings.⁹ Nwachukwu, Hamid and Bozic proposed performing cost analyses on implant technologies in order to better evaluate treatment costs, as understanding the value of the implant is a direct avenue by which orthopedic surgeons can influence cost.^{8,16}

The purpose of this study, therefore, is to identify the relationship between implant type and the inpatient cost of care for the treatment of isolated geriatric intertrochanteric femur fractures. The primary outcome being evaluated is the relationship

between implant cost and the total in-hospital cost of care. We hypothesize that implant cost will correlate to total cost of care.

Methods

Following Institutional Review Board (IRB) approval in 2018, we performed a retrospective review of intertrochanteric femur fractures treated from 2013-2017 at a metropolitan academic level 1 trauma center (Figure 1). Patients included in the study were ≥ 65 years old and had isolated and closed intertrochanteric femur fractures (31A) treated operatively with sliding hip screw (SHS) or cephalomedullary nail. Patients were identified using Current Procedural Terminology (CPT) codes 27244 and 27245. Radiographs were reviewed to identify construct type: sliding hip screw (SHS), short cephalomedullary nail (SCMN), and long cephalomedullary nail (LCMN). Each patient was also radiographically reviewed for their associated AO Foundation/Orthopaedic Trauma Association (AO/OTA) fracture classification grade.

Variables collected included age, gender, BMI, medical comorbidities, Charlson comorbidity index (CCI), age-adjusted CCI, ASA, length-of-stay (LOS), construct type, implant cost, and the incurred inpatient cost of care. The total cost of care for the inpatient stay was obtained using the time-driven activity-based method of costing where each individual charge description master (CDM) attributed to the patient is allocated using a relative value method to integrate both time and cost. All costs are reported in 2016 USD.

The primary outcome was the incurred inpatient cost-of-care: its relationship with the implant type and its attributed implant cost. Secondary study objectives included assessing the relationship between CCI and AO/OTA fracture patterns to total inpatient cost-of-care. Multivariable linear regression and goodness-of-fit analyses were used to determine

Table 1. Population Characteristics for Study Sample Stratified by the Construct Type, Between 2013-2018 (N = 287).

	Sliding Hip Screw (SHS) (n = 50; 17.4%)	Short Intramedullary Nail (IMN) (n = 111; 38.7%)	Long Intramedullary Nail (IMN) (n = 126; 43.9%)	p-value
Gender	Male: 22 (44.0%) Female: 28 (56.0%)	Male: 29 (26.1%) Female: 82 (73.9%)	Male: 32 (25.4%) Female: 94 (74.6%)	0.04¹
Age	78.8 + 8.5 [76.4, 81.2]	83.9 + 8.5 [82.3, 85.5]	84.2 + 8.0 [82.7, 85.6]	<0.01²
Body Mass Index (BMI)	24.6 + 5.6 [23.0, 26.2]	23.6 + 4.0 [22.5, 24.7]	25.2 + 4.2 [24.0, 26.4]	0.44 ²
AO/OTA Fracture Classification	31-A1: 32 (64.0%) 31-A2: 18 (36.0%) 31-A3: 0 (0.0%)	31-A1: 41 (36.9%) 31-A2: 63 (56.8%) 31-A3: 7 (6.3%)	31-A1: 13 (10.3%) 31-A2: 70 (55.6%) 31-A3: 43 (34.1%)	<0.01¹
Anesthesiologist Society of America (ASA) Score	2: 9 (18.0%) 3: 36 (72.0%) 4: 5 (10.0%) 5: 0 (0.0%)	2: 14 (12.6%) 3: 81 (73.0%) 4: 15 (13.5%) 5: 1 (0.9%)	2: 20 (15.9%) 3: 87 (69.0%) 4: 18 (14.3%) 5: 1 (0.8%)	0.89 ¹
Age-Adjusted Charlson Comorbidity Index (CCI)	5.3 + 2.5 [4.5, 6.0]	5.8 + 2.1 [5.4, 6.2]	5.8 + 1.9 [5.5, 6.1]	0.23 ²
Hospital Length of Stay	4.5 + 2.6 [3.8, 5.2]	4.9 + 2.9 [4.4, 5.5]	5.1 + 2.5 [4.6, 5.5]	0.42 ²
Total Implant Cost(s)	\$1342 + \$349 [\$1244, \$1440]	\$2574 + \$543 [\$2473, \$2676]	\$3355 + \$520 [\$3264, \$3446]	<0.01¹
Total Inpatient Cost(s)	\$17077 + \$8761 [\$14613, \$19541]	\$19314 + 7906 [\$17834, \$20794]	\$21372 + \$7647 [\$20030, \$22715]	0.04²
1-Year Readmission ^a	3 (6.0%)	7 (6.3%)	6 (4.8%)	0.87 ¹
1-Year Reoperation ^a	1 (2.0%)	5 (4.5%)	6 (4.8%)	0.69 ¹
90-Day Mortality	4 (8.0%)	19 (17.1%)	16 (12.7%)	0.27 ¹
1-Year Mortality	9 (18.0%)	34 (30.6%)	28 (22.2%)	0.16 ¹

A summary of the study populations' characteristics when stratified by the construct type.

Bolded text indicates a statistically significant p-value, $p < 0.05$.

¹Resulting p-value for a chi-square test between groups.

²Resulting p-value for a 1-way ANOVA F-test.

^a1-Year readmissions and reoperations only include admissions/procedures that are related to the index hip fracture procedure and only those captured within the original hospital system.

correlation between implant costs, inpatient cost of care, construct type, patient characteristics, and injury characteristics.

Results

A total of 287 intertrochanteric fractures meeting inclusion criteria were identified (Figure 1). Females comprised 204 of the 287 patients (71.1%). The mean age of the sample population was 83.1 + 8.5 [82.1, 84.1] years with an average BMI of 24.5 + 5.5 [23.9, 25.1]. Fracture pattern was primarily 31-A2, 151 (52.6%), followed by 31-A1, 86 (30.0%), and 31-A3, 50 (17.4%). The average age-adjusted Charlson comorbidity index (CCI) was 5.7 + 2.1 [5.5, 6.0]. A total of 50 (17.4%) patients were treated with sliding hip screw, with the remaining 111 (38.7%) and 126 (43.9%) being treated by short and long intramedullary constructs, respectively. A total of 16 (5.6%) of patients required readmission to the hospital as a result of the index surgical procedure and 12 (4.2%) ultimately required reoperation with non-union/malunion being the primary reason, 8 of 12 (66.7%).

Implant costs ranged from \$765.17 to \$5,045.62, averaging \$2,699 + \$879 [\$2,598, \$2,701]. Implant costs were highest among OTA 31-A3 fracture patterns, \$2,746, versus

31-A2, \$2287, and 31-A1, \$1,764 fracture patterns ($p < 0.01$) (Table 1). Age presented no discernable correlation to the derived implant cost ($r^2 = 0.03$) or resulting inpatient cost of care ($r^2 = 0.04$). Implant cost had a positive linear association with the overall inpatient cost of care ($\beta = 1.86$; $p < 0.01$) when adjusting for demographics, age-adjusted CCI, and OTA fracture pattern, but remains highly variable ($r^2 = 0.16$).

The total inpatient cost of care for the treatment of isolated geriatric IT fractures ranged from \$9,129.18 to \$64,210.70, averaging \$19,822. SHS had a mean implant cost of \$1,342 + \$349 [\$1,244, \$1,440]. Short intramedullary nail had a mean implant cost of \$2,574 + \$543 [\$2,473, \$2,676] and LCMN had a mean implant cost of \$3,355 + \$520 [\$3,264, \$3,446]. Patients receiving a SHS had the lowest mean total cost of care, at \$17,077, followed by short and long intramedullary nails, \$19,314 and \$21,372, respectively. The coefficient of variation in implant was highest in SHS, 26.0%, followed by short intramedullary nails, 21.1%, and long intramedullary nails, 15.5%. This pattern was paralleled in the coefficient of variation for inpatient cost of care when stratified by construct type: SHS, 51.3%, short intramedullary nail, 40.9%, and long intramedullary nail, 35.8%.

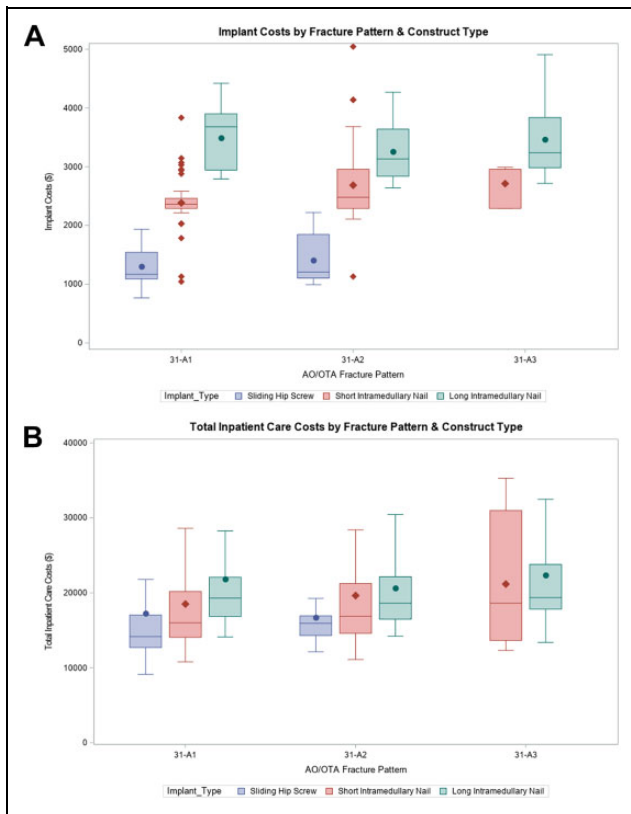


Figure 2. Implant costs (A) and inpatient care costs (B) stratified by both the AO Foundation/Orthopaedic Trauma Association (AO/OTA) fracture pattern and the construct type.

Both implant cost and total cost of care were unique when compared across construct type ($p < 0.01$ and $p < 0.01$, respectively). When construct type and fracture pattern were compared to the total cost, patients with a type 31-A1 fracture pattern treated with SHS had a significantly lower total cost than types 31-A2 and 31-A3 (Figure 2A). Additionally, when construct type and fracture pattern were compared to total implant cost, type 31-A1 treated with SHS had a significantly lower implant cost and less variability (Figure 2B).

Discussion

Patients with geriatric hip fractures have expensive and widely varying hospital courses. Determining the value of treating hip fractures has been difficult because drivers of cost have remained elusive. Identifying these cost drivers will be necessary as we move toward bundled payments so that reimbursements can be adjusted for risk. The purpose of this study, therefore, was to identify the relationship between implant cost and the total cost of care for the treatment of isolated geriatric intertrochanteric femur fractures. Our hypothesis was that implant cost would correlate to total cost of care.

We found that implant cost had a positive relationship with the overall inpatient cost of care, but when adjusting for demographics, age-adjusted CCI, and OTA fracture pattern, there was high variability. However, implant cost and total cost of

care were unique when compared across construct type. There was no predictive value between implant type and total cost of care across the sample. There was, however, a significantly lower total cost of care in stable IT fractures treated with SHS. Additionally, 31-A1 fracture types treated with SHS had a significantly lower implant cost and less variation in cost.

Multiple randomized controlled trials (RCTs) have shown no significant difference in outcomes between SHS and IMN constructs for the treatment of uncomplicated IT fractures.¹⁷⁻²⁰ Alternatively, a meta-analysis of 19 studies, conducted by Wynn Jones et al. in 2006, identified higher failure and reoperation rates in IMN constructs when compared to SHS constructs.¹⁷ Our study also highlights a favorable 1-year reoperation rate for SHS, 2.0%, compared to IMN constructs, 4.6%, but was not powered to reach significance ($p = 0.69$). This would lead to increased care costs incurred due to both secondary procedures and consequent treatment following reoperation or conversion surgery. However, there has been a dramatic increase in the use of IMN for treatment of IT fractures since their introduction.^{21,22} Studies have revealed that orthopedic surgeons are unaware of the cost of these implants.^{23,24} With the healthcare system becoming increasingly interested in the value of orthopedic care, and in particular, the impact an orthopedic surgeon has on cost of care, implant selection may be utilized as an opportunity to decrease costs.^{8,16,25}

Many orthopedic subspecialties have evaluated how implant selection affects cost of care. Cavallero et al. evaluated the cost and outcomes of locking versus nonlocking (NL) implants for the treatment of bicondylar tibial plateau (BTP) fractures. The locking group had a 73% higher cost than the NL group, but both groups had similar functional outcomes, concluding that NL implants for treatment of BTP fractures improved the value of care provided.²⁶ Egol et al. presented a similar conclusion when looking at treatment of hip fractures. New York University Hospital for Joint Disease implemented a classification-based hip fracture implant selection algorithm to standardize treatment of intertrochanteric femur fractures, resulting in an 18% reduction in cost per patient. The largest reduction in cost came from using fewer cephalomedullary nails for stable intertrochanteric femur fractures.²⁷

In orthopedic spinal surgery Shen et al. investigated the use of low density versus high density pedicle screws in adolescent idiopathic scoliosis (AIS). There was a significant difference in operative time, blood loss, and implant cost between the 2 groups, with no significant difference in outcomes.²⁸ Similarly, Yermaneni et al. evaluated the components of the variation seen in total inpatient costs for Adult Spinal Deformity (ASD) who underwent corrective spine surgery. As suspected, each additional level fused significantly increased the total episode of care (EOC) cost versus use of bone morphogenic protein (BMP) and posterior approach lowered costs by \$10,500 and \$9,400, respectively. When implants, interbody fusions, biologics and surgical approach were added to the mixed model analysis, there was a significant increase in total cost of care variation.²⁹ These findings suggest that surgeon decisions,

such as implants and techniques used, have a significant impact on the total cost of care. However, while these findings are specific to spine surgery and lacks the unique characteristics for geriatric patients and hip fractures that could be converted for joint replacement, these studies quantify the cost savings that can be created with informed surgeon-decision making. These studies highlight the potential impacts surgeons are able to achieve with strategic implant selection and construct consistency.

Implant selection has already been targeted as a modality to contain costs and help reduce the overall total cost of care in bundled payment trials.^{8,9,30} When Baptist Health System trialed Acute Care Episodes (ACE) and Bundled Payments for Care Improvement (BPCI) demonstration projects in patients undergoing total joint arthroplasty, costs per patient decreased, with the majority of savings due to reductions in implant costs. Implant costs themselves decreased by 29% over a 2-year period in the BPCI project and accounted for 80% of the total savings in a three-year period in the ACE project.¹² Additionally, when Plasis et al. defined the overall cost for total hip and knee arthroplasties using time-driven activity-based costing they found implant selection accounts for 45% and 32% of the cost, respectively.³¹ They subsequently emphasized the importance of orthopedic surgeons recognizing how their preferences of implant selection impact the cost of care.

Previous avenues to educate and guide surgeons on preferred, cost-effective implants were seen in the “Red-Yellow-Green Implant Guidance Tool” used at the University of Maryland Medical Center. With this model, implant expenditures decreased by 20%, and the use of “green” (preferred) implants increased from 14% to 70% over the 12-month trial period.

Another strategy to influence surgeons’ fixation device is by algorithms and standardization of care. As previously stated, there has been a transition from SHS construct to cephalomedullary nails among young orthopedic surgeons, without evidence of implant superiority or improvement in outcomes.^{18,21} However, Egol et al. were able to reduce cost per patient by 18% by implementing an algorithm for treating hip fractures.³²

Orthopedic surgeons are among the highest users of medical devices, with physician preference accounting for 1/3 of hospital supply costs, but historically orthopedic surgeons have not been incentivized to use 1 implant over another aside from their own preference. With upcoming changes in payment models, there is an opportunity to create physician gainsharing to incentivize less expensive implant selection. Under the gainsharing model, physicians would see a portion of the savings if certain metrics are met. A survey at the 2006 AOA meeting resulted in 61% of respondents expressing interest in implementing gainsharing as a model to incentivize providers to select cost-effective implants. An example of successful implementation of gainsharing and bundled payment programs was seen at Baptist Health Systems where they were able to reduce implant cost with gainsharing as it incentivized surgeons to choose a cost-effective implant.¹² Additionally, in Althausen and Mead’s experience with bundled payments, surgeons were incentivized with internal cost savings (ICS)

gainsharing, resulting in over \$350,000 available to participating physicians.⁹

The increasing complexity of healthcare expenditures and payment systems requires surgeons to take an active role in minimizing costs. Value-based payment models will be mandatory in the near future, and in order to create a higher value of care, cost-effective implants need to be utilized.

This study had multiple strengths and weaknesses. A strength is that all patients in the study sample were isolated geriatric intertrochanteric hip fractures, minimizing the risk of confounding results from a heterogeneous hip fracture population. Additionally, we assessed the relationship between implant cost and inpatient cost of care across a multitude of variables, including injury severity, demographics, implant type, and overall medical comorbidities. Furthermore, cost data on a sample of this size has not been previously reported. This is the first study to our knowledge to use time-driven activity-based costing (TDABC) methods to evaluate the cost of care for intertrochanteric femur fractures. Limitations include the retrospective nature of the study, as well as the analysis being performed at a single level-I trauma center, limiting generalizability to other orthopedic populations.

Conclusion

The cost of care for geriatric hip fractures is poorly understood and difficult to determine. With the healthcare system becoming increasingly interested in the value of orthopedic care and with alternative payment models on the horizon, implant selection should be utilized as an opportunity to decrease costs and increase the value of care provided to patients.

Declaration of Conflicting Interests

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