Femoral Neck Shortening Is Associated with Worse Functional Outcome: Analysis of the Prospective Multicenter Study of Hip Fracture Outcomes in China (SHOC)

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Purpose: Young femoral neck fracture patients (age ≤55 years) require surgical fixation to preserve the native hip joint and accommodate increased functional demands. Recent reports have identified a high incidence of fracture shortening and this may have negative functional consequences. We sought to determine if fracture shortening is associated with poor functional outcome in young femoral neck fracture patients.

Methods: 142 femoral neck fracture patients ages 18-55 years were enrolled in a prospective cohort study in three Chinese hospitals. Patient, injury, and treatment variables were recorded at injury, 6 weeks, and 3, 6, 12, and 24 months. Patient-reported functional outcomes were measured with the Harris Hip Score (HHS), Timed Up and Go test (TUG), and Short Form (SF)-36 Physical Component Summary (PCS) at 1 year. Radiographic fracture shortening was measured along the long axis of the femoral neck and corrected for magnification. Severe shortening was defined as ≥10 mm. The primary analysis measured associations between severe radiographic shortening and functional outcomes at 1 year post-fixation. Continuous variables were summarized with their mean ± standard deviation. Statistical significance was set at $P \leq 0.05$.

Results: 107 patients had complete radiographic and functional outcomes available for analysis at 1 year. The mean age of participants was 44.0 ± 10.7 years and 54% were male. 53% of fractures were displaced and 38% were vertically orientated (Pauwels Type 3). The mean functional outcome scores were: HHS 90 ± 11, TUG 12 ± 5 seconds, and PCS 49 ± 8. Major shortening occurred in 13% of patients and was associated with worse functional outcome scores: HHS mean difference 10 ($P = 0.02$), TUG mean difference 3 seconds ($P = 0.08$), and PCS mean difference 5 ($P = 0.05$).

Conclusion: Severe shortening is a clinically significant complication following fixation of young femoral neck fractures, occurring in 13% of patients in this population. The principle of fracture site compression utilized by modern constructs may promote healing; however, excessive shortening is associated with worse patient-reported outcomes and objective functional measures.

A Case-Control Study of Total Hip Arthroplasty After Failed Proximal Femoral Fracture Fixation

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Background/Purpose: Fractures of the proximal femur are becoming more prevalent as the population ages. Femoral neck and intertrochanteric fractures account for most proximal femoral fractures and although the initial treatment of these two injuries may differ, the salvage procedure for failed internal fixation is often a conversion to total hip arthroplasty (THA). The use of THA for failed internal fixation of hip fractures can restore function and reduce the need for subsequent reoperations; however, the distorted bony anatomy, scar tissue, and potential hardware around the hip result in a more challenging procedure in this subset of patients. The aim of this study was to investigate the clinical and radiographic outcomes in patients who have undergone THA after a failed fixation of a proximal femoral fracture.

Methods: This retrospective case-control study compared findings of patients who underwent THA after failed open reduction and internal fixation (ORIF) of a proximal femoral fracture to a primary THA for nontraumatic osteoarthritis. From 2004 to 2014, 40 patients received a THA after failed internal fixation of a previous proximal femur fracture. The matched cohort of patients was matched for date of operation, age, gender, and type of implant to control for their confounding effects on outcomes. The outcome measurements included length of surgery, drop in hemoglobin, length of hospital stay, blood transfusion rates, medical complications, dislocations, revision procedures, and clinical outcome scores at latest follow-up. Statistical analysis was performed using the Student t test and vhi-squared test with significance set at a P value <0.05.

Results: The cohort of patients with a salvage THA included 18 male and 22 female patients with a mean age of 73 years (range, 28-96 years) and mean follow-up of 3.1 years (range, 1-8.3). Those with failed internal fixation included 12 intertrochanteric fractures (10 DHS [dynamic hip screw], 1 IM [intramedullary] nail, 1 blade plate) and 28 femoral neck fractures (21 cannulated screws, 6 DHS, 1 blade plate). The mean time between the internal fixation of the fracture and the THA was 2.1 years (standard deviation [SD], 2.7 years) for intertrochanteric fractures and 8.5 years (SD, 13.8 years) for femoral neck fractures (P = 0.03). There was no difference in the time to THA between DHS and cannulated screws for femoral neck fractures. The failed fixation group had longer procedures with a mean operative time of 99.49 ± 11.80 minutes compared to 77.20 ± 7.53 minutes for the primary THA group (P <0.05). The drop in hemoglobin from preoperative to postoperative day three was greater in the failed fixation group with a mean drop of 53.52 ± 6.08 g/L compared to 43.06 ± 4.68 g/L in the primary THA group (P <0.05). The transfusion rate was 50% in the failed fixation group compared to 25% in the primary THA group (P <0.05). There was one THA revision in the failed fixation group for infection and Vancouver B2 periprosthetic femur fracture. Additionally, there was also one case of dislocation in the failed fixation group that was treated by closed reduction and did not require revision. There were no revisions or dislocations in the primary THA group. Length of admission and medical complications

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were not significantly different between the groups. The functional outcome was assessed using a standardized hip score and was found not statistically different between the groups at final follow-up (P = 0.41).

Conclusion: Conversion to THA after failed fixation of proximal femur fractures results in comparable clinical results to primary THA with an increased operative time, blood loss, and blood transfusion rate. The findings from this study support that the initial management of proximal femoral fractures by internal fixation does not negatively affect the outcomes of a salvage THA.

Hip Fracture Treatment at Orthopaedic Teaching Hospitals: Better Care at a Lower Cost

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Background/Purpose: Recently, attention has been directed towards the seemingly high cost of academic medical centers compared to community hospitals for certain procedures. Few studies have examined the effect of teaching hospital status on outcomes for patients with operative hip fractures. None have excluded hospitals without orthopaedic residents from the teaching hospital designation. The purpose of this study is to examine the effect of orthopaedic teaching hospital (OTH) status, in particular, on hospital quality measures and mortality while controlling for potential confounding factors.

Methods: All isolated hip fractures admitted to a New York State hospital from 2000 to 2011 were queried from an electronic administrative database (SPARCS). Patients less than 55 years of age, those transferred from outside hospitals, and nonoperative cases were excluded. Charlson comorbidity index (CCI) was calculated to assess comorbidity burden. All orthopaedic residency programs in New York State were contacted to determine the specific hospitals that hosted orthopaedic surgery residents during the study period. These were designated as orthopaedic teaching hospitals. Multivariate, backwards-stepwise linear and logistic regression analyses were performed to determine how orthopaedic teaching hospital designation impacts in-hospital mortality, length of stay (LOS), and total hospital charges. Age, gender, race, CCI, insurance status, fracture type, trauma level, and hospital bed size were controlled for in the multivariate analysis. $P < 0.05$ was considered significant. Means are reported with ±1 standard deviation.

Results: Of the 161,080 isolated hip fractures that met inclusion criteria, 57,208 were treated at OTH and 103,872 were treated at nonteaching hospitals (NTH). Univariate analysis shows that mean total hospital charges were higher at OTH ($40,443 ± $45,753) than NTH ($31,430 ± $29,512) ($P < 0.0001$), LOS was shorter at OTH (7.99 ± 9.6 days) compared to NTH (8.09 ± 7.7 days) ($P < 0.017$) and mortality was lower in OTH (3.0%) compared to NTH (3.7%). In the multivariate total charges analysis, in addition to demographic differences, we identified total hospital beds as a significant confounding variable. For every 100 hospital beds, total charges increased 9.8% (odds ratio [OR] = 1.098, $P < 0.001$). Without controlling for hospital beds, OTH designation increases costs 19.9% (OR = 1.199, $P < 0.000001$). However, when controlling for the number of hospital beds, OTH status decreases costs by 4.5% (OR = 0.957, $P < 0.001$). Additionally, multivariate analysis found that OTH status decreased LOS by 9.1% and mortality by 24%, confirming the univariate trends.

Conclusion: While OTH may appear to have higher hospital charges for operative hip fractures, this is because they tend to be larger hospitals, which is an independent risk factor for increased charges. When controlling for hospital bed number, OTH status is associated with lower hospital charges, LOS, and lower in-hospital mortality. With the Affordable Care Act incentivizing hospital consolidation, these data suggest that increasing investment in graduate medical education programs at larger hospitals may be one strategy to achieve higher quality care at a lower cost.

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Is it Safe to Operate on Therapeutically Anticoagulated Hip Fractures?

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Purpose: Delays in surgical intervention for hip fractures have been shown to increase morbidity. Therapeutic international normalized ratios (INRs) are often a reason for surgical delay. Limited data exist demonstrating that optimizing INR levels to subtherapeutic values decreases the morbidity and mortality of surgery. The purpose of this study was to compare the safety of surgical intervention in hip fracture patients with subtherapeutic and therapeutic INR values.

Methods: A multicenter, retrospective analysis was performed on prospectively collected data for a consecutive series of surgically managed hip fracture patients over a 7-year period. Exclusion criteria included patients on any anticoagulant other than warfarin or aspirin or if they had an elevated INR from an underlying medical condition. Fresh-frozen plasma and vitamin K were administered per surgeon discretion. Patients with operative INR values of 1.5 to 2.0 and 2.0 to 3.0 were compared to patients with operative INR values under 1.5 (control). The primary outcome measure was the rate of major complications (inpatient death, increased level of care, acute infection, cardiovascular event, or return to operating room [OR]). Secondary outcome measurements include all complications, the rate of blood transfusions, 30-day mortality, length of stay, and time to operative intervention from admission. A Fisher exact test was employed to test the categorical variables and t tests were used for continuous variables with statistical significance set at 0.05.

Results: 730 patients who sustained hip fractures were identified with 222 on chronic warfarin therapy. 107 patients had INR values between 1.5 and 2.0 at the time of surgery, and 84 patients had INR values between 2.0 and 3.0 at the time of surgery. 539 patients had operative INR values less than 1.5 (control). Control group demographics including age, injury, American Society of Anesthesiologists (ASA) score, and implant type were not statistically different than the therapeutic INR patients. Only length of stay was statistically different in the 1.5-2.0 group compared to the control cohort (6.65 vs 5.71 days, P = 0.039). All other measurements did not reach statistical significance (Table 1). No statistical difference was found in the 2.0-3.0 INR group compared to the control on any outcome measure (Table 2).

Conclusion: Delaying surgical intervention for an INR less than 3.0 in hip fracture patients may have limited clinical benefit. It is unclear if reversing the INR of patients on chronic anticoagulation is necessary. Expedient surgical treatment of therapeutically anticoagulated patients demonstrates no increased rate of transfusions, 30-day mortality, or complications.

	Factors[1]	Overall	Cluster 1	Cluster 2	Cluster 3
Risk[2]	Pain	4.6 (2.7)	3.3 (2.2)	5.1 (2.4)	7.1 (2.1)
	Depression	7.7 (5.9)	3.8 (3.5)	8.4 (4.0)	16.3 (4.6)
	PTSD	16.7 (14.6)	7.6 (7.3)	16.8 (9.0)	41.3 (10.7)
	Alcohol Abuse, n (%)	80 (12)	25 (8)	42 (17)	13 (12)
	Tobacco Use, n (%)	198 (29)	41 (13)	97 (38)	60 (52)
Protective[3]	Resilience	6.5 (1.6)	7.1 (1.3)	6.2 (1.6)	5.5 (1.7)
	Social Support	2.1 (1.0)	3.6 (0.7)	2.9 (1.0)	2.5 (1.3)
	Return to Work	7.2 (2.9)	9.1 (1.3)	5.9 (2.8)	5.0 (2.9)
	Manage Finance	5.9 (3.3)	8.2 (2.1)	4.0 (2.7)	3.6 (3.0)

[1] Results expressed as mean (SD), except where otherwise indicated.
[2] Ranges (clinical cut-point): Pain: 0-10 (≥5); Depression: 0-30 (≥10); PTSD: 0-68 (≥30).
[3] Ranges: Resilience: 0-8; Social support: 0-4; Return to work: 1-10; Manage finance: 1-10.

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Short vs Long Cephalomedullary Nails for Fixation of Stable vs. Unstable Intertrochanteric Femur Fractures at a Level 1 Trauma Center

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Objectives: To compare failure and complications associated with short cephalomedullary nail (SCMN) versus long cephalomedullary nail (LCMN) fixation for stable vs. unstable intertrochanteric femur fractures at a level 1 trauma center.

Design: Retrospective Cohort Study. Setting: Academic Level 1 Trauma Center. Patients/Participants: 201 adult patients with non-pathologic intertrochanteric femur fracture without subtrochanteric extension (OTA 31-A1.1-3, 31-A2.1-3, 31-A3.1-3) that were treated with a SCMN (n=70) or LCMN (n=131) between 2000-2012 and had at least 6 months follow-up. Intervention: ORIF of intertrochanteric femur fracture with either an SCMN or LCMN. Main Outcome Measurements: Treatment failure rate, defined as cutout, non-union, fracture, collapse of more than two centimeters on follow-up radiographs, or revision surgery, not including removal of symptomatic hardware.

Results: In the stable fracture group (N=81), there was no difference in failure between SCMNs and LCMNs (p=0.35). In this group, there were three failures with SCMNs (2 cut-outs, 1 collapse) and one failure with LCMN (1 cut-out). In the unstable fracture group (N=120), there was no difference in failure between SCMNs vs LCMNs (p=0.47). In this group, there were four total SCMN failures (12.9%) (1 cut-out, 2 non-unions, 1 collapse), and seven LCMN failures (7.9%) (2 cutouts, 3 non-unions, 2 collapse). There were no periprosthetic fractures in the either group.

Table 1. Failures, Complications, and Mortality in Unstable Fracture Patterns (OTA class 31-A2.1-3.3)

	Short Nail (N=44)	**Long Nail (N=146)**	**P value**	**Adjusted P value**	**Odds/Hazard ratio (Long vs. Short)**
Failure	7 (15.9%)	9 (6.2%)	0.0413[c]	0.018[log]	0.26 (0.08 ~ 0.79)[OR]
- Cut-out	2	1	--	--	--
- Non-union	3	3	--	--	--
- Fracture	0	0	--	--	--
- Collapse	0	2	--	--	--
- Revision Surgery	2	3	--	--	--
Complications	14 (31.8%)	39 (26.7%)	0.508[c]	0.282[log]	0.65 (0.3 ~ 1.42)[OR]
Mortality	20 (45.5%)	41 (28.1%)	0.03[s]	0.04[ph]	0.68 (0.47 ~ 0.99)[HR]
1 year mortality	9 (24.5%)	19 (13%)	0.22[c]	0.96[log]	1.04 (0.3 ~ 3.54)[OR]
30 day mortality	3 (6.8%)	6 (4.1%)	0.43[f]	0.61[logf]	0.67 (0.15 ~ 3.1)[OR]

[c] Chi-square test, [f] Fisher's exact test [log] Logistic regression adjusting for sex, age, Iezzoni comorbidities, days since surgery (evaluated on 12/1/2013), and tip apex distance. [s] Log-rank test comparing survivor functions,[logf] Firth logistic regression adjusting for sex, age, Iezzoni comorbidities, days since surgery (evaluated on 12/1/2013), and tip apex distance. [ph] Cox proportional hazard model comparing survivor functions adjusting for sex, age, Iezzoni comorbidities, days since surgery, and tip apex distance. [OR]: Odds ratio, [HR]: Hazard ratio

Conclusions: SCMNs and LCMNs exhibit similar failure rates in both stable and unstable intertrochanteric femur fractures.

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Myth or Taboo? Use of Long-Threaded Screws in Femoral Neck Fractures

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Background/Purpose: The conventional osteosynthesis technique for these fractures is closed reduction (if necessary) and fixation with multiple cannulated screws or a sliding hip screw. The conventional technique for screw osteosynthesis of femoral neck fractures involves the insertion of cannulated screws in an inverted triangle configuration near the neck cortex without the screw thread crossing the fracture line. However, weight bearing sometimes results in significant shortening of the femoral neck and protrusion of cannulated screws, necessitating their removal because of soft-tissue irritation. We hypothesized that the use of long-threaded screws, in which the thread crosses the fracture line, would hold the thick trabeculae of the femoral neck and head together, thereby decreasing screw sliding and femoral neck shortening in 31-B1 fractures. The purpose of this study was to compare clinical and radiological results of this new osteosynthesis technique (using long-threaded screws) with those of the conventional technique (using shor- threaded screws).

Methods: We compared patients with femoral neck fractures (OTA 31-B1) who underwent osteosynthesis using three conventional short-threaded screws (Group S, n = 38) or the new technique using long-threaded screws after compression (Group L, n =38). Surgery was performed with the patient on a fracture table under general or fluoroscopy-guided spinal anesthesia. The fractures did not undergo disimpaction; however, posterior tilt of the capital fragment (apex anterior angulation) was reduced by internally rotating the leg and applying pressure from the front. Each fracture was first fixed with three 7.0-mm cannulated screws with 16-mm thread inserted percutaneously parallel to each other (within approximately 5°) without convergence or dispersion. When weakening of the lateral femoral cortex occurred, washers were used. The inferior-center screw was inserted from the lateral cortex of the subtrochanteric area, where it was not distal to the center of the lesser trochanter, and along the medial cortex of the femoral neck. The superior-anterior and superior-posterior screws were inserted to form an inverted triangle. The threads were placed in the femoral head and did not cross the fracture line. Compression was performed by tightening the cannulated screws. In Group L, the three screws were then replaced with long-threaded screws (32-mm thread) to hold the proximal and distal fragments together.

Results: Bony union occurred in all cases during follow-up (mean, 42 months). Mean screw sliding distance was 1.38 mm (standard deviation [SD], 1.77; range, 0.00-7.72) for Group L and 3.30 mm (SD, 2.81; range 0.03-12.22) for Group S (P <0.001). Mean Harris Hip Score was 90.6 for Group L and 82.6 for Group S (P = 0.001). Avascular necrosis of the femoral head occurred in one patient (2.6%) in Group L and two patients (5.3%) in Group S (P = 1.000). Results of univariate regression analysis indicated that screw sliding distance was significantly associated with age (P = 0.020) and screw type (P = 0.001). These associations were confirmed by multiple regression analysis (age, P = 0.009; screw type, P <0.001).

Conclusion: Replacement of short-threaded screws with long-threaded screws after compression provided better control of screw sliding and decreased femoral neck shortening, thereby improving functional recovery.

Table 1. Demographic and clinical characteristics of patients treated with conventional osteosynthesis using short-threaded screws and those treated with the new technique using long-threaded screws.

	Short-threaded (n=38)	Long-threaded (n=38)	p-value
Age, y	67.1±14.5	66.7±17.9	0.979
Female, n (%)	27 (71.1%)	26 (68.4%)	0.803*
Body mass index, kg/m^2	22.4±3.6	21.2±3.1	0.363
Bone mineral density, n	-2.1±1.1 (33)	-2.3±0.7 (30)	0.474
Femur neck shortening, mm	8.36±6.12	3.14±3.14	<0.001
Sliding distance of screw, mm	3.30±2.81	1.38±1.77	<0.001
Harris Hip Score	82.6±12.8	90.6±6.5	0.001
AVN, n (%)	2 (5.3%)	1 (2.6%)	1.000†
Removal of screw, n (%)	8 (21.1%)	5 (13.2%)	0.361*

Results are expressed as n (%) or mean±standard deviation. P-values were determined by Mann–Whitney U test, chi-square test,* and Fisher's exact test†

AVN: avascular necrosis of the femoral head

Table 2. Predictors of screw sliding distance.

Variable	Univariate linear regression			Multiple linear regression		
	β	SE	p value	β	SE	p value
Age	0.041	0.017	0.020	0.053	0.020	0.009
Gender	-0.307	0.633	0.630			
BMI	0.116	0.085	0.180			
BMD	0.022	0.327	0.946			
Group	-1.916	0.538	0.001	-2.080	0.538	<0.001

SE, standard error; BMI, body mass index; BMD, bone mineral density.

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Percutaneous Cannulated Screw Versus Dynamic Hip Screw Fixation for Intracapsular Femoral Neck Fracture: A Comparative Study

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Background/Purpose: Choice of internal fixation for undisplaced femoral neck fractures has been a controversial topic. Historically surgeons have preferred percutaneous cannulated screws over dynamic hip screw fixation. Studies have, however, shown no significant different between the two implants. Osteosynthesis with cannulated screw fixation is a less invasive technique, with less soft-tissue stripping. However, early loosening of the screws may occur if the lateral cortex is damaged from osteoporosis. In contrast, dynamic hip screw (DHS), which is a screw-plate system with fixed angles, can achieve more stable fixation in patients with osteoporosis. However, the disadvantages of DHS technique are larger skin incisions and more soft-tissue dissection. The purpose of this study was to compare the period of union, functional outcomes, and complications of patients with femoral neck fracture treated with percutaneous cannulated screws versus DHS. This study also aimed to assess the incidence of femoral neck shortening in patients with femoral neck fractures treated with multiple cannulated screws.

Methods: This was a retrospective analysis of a prospective femoral neck fracture database to include a cohort of all patients between 1999 and 2013, with undisplaced or minimally displaced intracapsular fractures treated with either percutaneous cannulated screws (n = 120) or a DHS fixation (n = 109). All patients were followed for at least 12 months. Data were reviewed for failure of the implant with radiographic evidence and the cause for revision documented. The latest AP radiograph of the fractured hip was compared with that of the contralateral uninjured hip for femoral neck shortening using the electronic images on the PACS (patient archiving and communication system).

Results: A total of 229 patients, with 109 in the percutaneous cannulated screw group and 120 in the DHS fixation group, were assessed. Both groups were similar in respect of injury mechanisms, injury-surgery interval, gender, and age (all P values = 0.29). In the cannulated hip screw fixation group there were 11 revisions surgeries compared to 4 in the DHS group ($P < 0.05$). Indications for revision included progression of osteoarthritis (n = 1), early failure of metal work (n = 1), and osteonecrosis (n = 9)(in the cannulated screw group. In the DHS group, indications for revision included osteoarthritis (n = 1) and osteonecrosis (n = 3). The shortening of femoral neck did not show significant difference in the two groups.

Conclusion: In our study, there was increased risk of osteonecrosis and failure in cannulated screw fixation group compared to the DHS fixation in the management of undisplaced femoral neck fracture. In conclusion, although DHS fixation requires a larger skin incision and more soft-tissue dissection, its use in elderly patients with osteoporosis is preferred due to its simplicity, efficacy, and high overall success rate.

Relationship Between the Charlson Comorbidity Index and Cost of Treating Geriatric Hip Fractures: Implications for Bundled Payment

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Background/Purpose: In the last decade, the incidence of hip fractures has dramatically increased, largely due to an aging population. With current costs of treating a hip fracture on the rise, a bundled payment system has been proposed to contain costs by paying hospitals and physicians a single amount for the treatment of a single injury. Prolonged hospital length of stay (LOS) has been identified as a major driver for costs in hip fracture surgery, but few studies have investigated potential predictors of LOS in patients with these injuries. The Charlson Comorbidity Index (CCI), a validated predictor of mortality based on comorbidities, succinctly summarizes a patient's overall health status with a score ranging from 0 (no risk) to 35 (severe risk). The purpose of our study was to assess if a patient's CCI score could utilized as a tool to predict LOS in geriatric hip fracture patients.

Methods: Through a retrospective chart analysis, patients over 60 years of age presenting with a low-energy hip fracture to a Level I trauma center from January 2000 to December 2009 were identified. Types of surgery included total hip arthroplasty (THA), hemiarthroplasty (hemi), cephalomedullary nailing (CMN), open reduction and internal fixation (ORIF), or closed reduction and percutaneous pinning (CRPP). Data were collected on LOS, age, gender, and comorbid conditions, from which the CCI was calculated. Linear regression analysis was used to evaluate statistical significance of the impact of surgery type on LOS, after controlling for age, gender, and CCI score. Inpatient financial services provided the estimated cost of an inpatient stay ($4530/night).

Results: Of the 720 charts reviewed, 615 patients met inclusion criteria and were included in analysis. After controlling for age, gender, American Society of Anesthesiologists score, body mass index (BMI), race, smoking status, and anesthesia type with linear regression analysis, patients with an increased CCI score had a statistically significant increased LOS ($P = 0.014$). Compared to patients with a CCI of 0, patients with a CCI score of 1 stayed an average of 0.7 days longer and incurred $4303.50 more in costs. Patients with a CCI score of 2, on average, had an increased LOS of 1.92 days compared to a patient with a CCI of 0, and incurred $8697.60 in additional costs.

Conclusion: This is the first study to demonstrate the value of using CCI as a predictor for LOS in geriatric hip patients. The higher CCI scores were shown to correlate with prolonged LOS following treatment for a hip fracture, and subsequently higher hospital costs. This study suggests that the CCI score may be utilized as a valuable tool to predict resource utilization in patients with geriatric hip fractures.

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Relationship between the Charlson Comorbidity Index and Cost of Treating Geriatric Hip Fractures: Implications for Bundled Payment

Figure 1: Mean length of stay per CCI

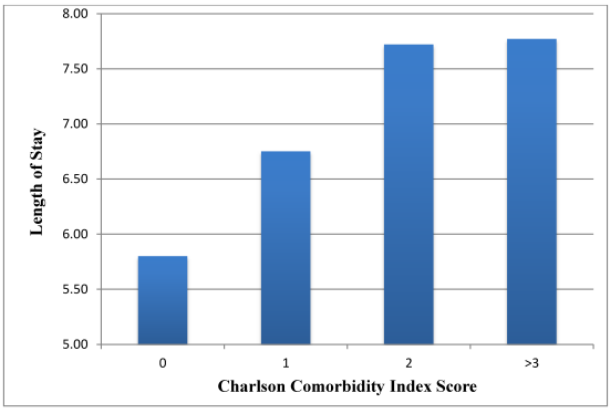
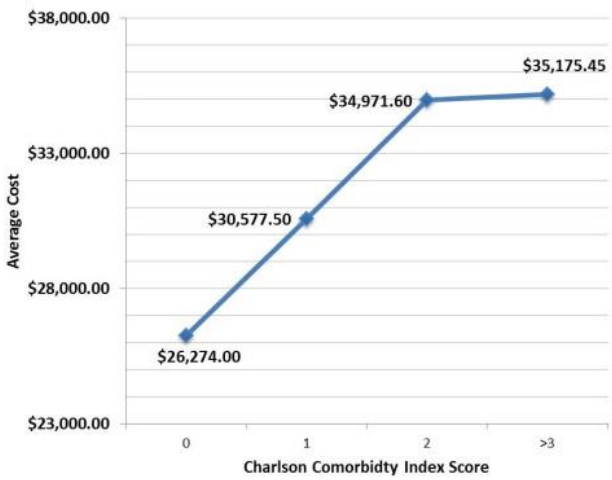


Figure 2: Mean cost of stay per CCI



Missing Data May Invalidate Hip Fracture Database Studies

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Purpose/Background: National databases are increasingly being used for research in orthopaedics, as they offer significant power for analyses. However, these databases have significant limitations. One limitation that has received sparse mention in the literature is the prevalence of missing data. Studies using these databases often do not mention the percent of missing data for each variable used, and do not make note of how patients with missing data are incorporated into analyses. This study uses the American College of Surgeons National Quality Improvement Program (ACS-NSQIP) database to illustrate how different treatments of missing data can significantly skew results.

Methods: Patients who underwent hip fracture surgery between 2005 and 2013 were identified from the ACS-NSQIP database using Current Procedural Terminology (CPT) codes. Demographics, comorbidities, and type of procedure were tabulated for each patient and the percent of missing data was noted for each variable. These variables were tested for association with "any adverse event" using two separate multivariate regressions that used the two most common treatments for missing data. In the first regression, patients with any missing data were simply excluded. In the second regression, missing data were treated as a negative, or "reference" value. The results of these regressions were compared in order to determine how the different treatments of missing data can affect the results of hip fracture studies using the ACS-NSQIP database.

Results: A total of 26,066 hip fracture patients were identified. The average age was 80.1 ± 10.9 years (mean ± standard deviation). The following rates of missing data were found for each demographic category: 0.00% for age, 0.05% for sex, 12.25% for body mass index (BMI), and 18.19% for race. The rate of missing data was 70.94% for each of the following comorbidities: alcohol use, pneumonia, esophageal varices, history of myocardial infarction, previous percutaneous coronary intervention, previous cardiac surgery, angina, peripheral vascular disease, rest pain, impaired sensorium, coma, hemiplegia, history of transient ischemic attack, stroke with/without neurologic deficit, central nervous system tumor, quadriplegia, chemotherapy, and radiotherapy. Multivariate logistic regressions for the association of demographics, comorbidities, and procedure characteristics with any adverse event within 30 days of surgery were performed with the two most common techniques for handling missing data: excluding patients with missing data, and treating missing data as the negative, or "reference" value. As seen in Table 1, these different techniques lead to finding vastly different significant risk factors for adverse events on multivariate analysis. Out of 17 risk factors found to be significantly associated with adverse events in either analysis, only six of these risk factors were common between the two regressions.

Conclusion: This study illustrates that a significant amount of missing data can be found in a hip fracture sample drawn from the ACS-NSQIP and extreme caution needs to be taken when selecting variables for inclusion in analyses. Specifically, 19 comorbidity variables have

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70.94% missing data, as they are now only collected at certain ACS-NSQIP participating sites. This is not made clear in the basic participant user manual distributed with the data set and researchers must be diligent when using data from more recent years. In addition, as shown in this sample, the treatment of missing data can significantly affect the results of hip fracture studies performed with this data set. There are multiple studies in the literature that have used this cohort of hip fracture patients in the ACS-NSQIP, and the majority of these studies fail to comment on the amount of missing data or how it was treated in analyses. This study raises significant questions about the validity of these studies and it is important for researchers to be aware of the limitations of databases when designing, performing, and evaluating such investigations. It is critical that studies using these data sources report how missing data are handled.

Table 1. Results of multivariate analysis for any adverse event with differing treatments of missing data.

	After excluding patients with missing data (n=5,760)		Missing data treated as negative (n=26,066)	
Risk Factor	OR	P-value	OR	P-value
Cerebrovascular accident	1.4	0.021	1.4	0.003
Preoperative pneumonia			1.9	0.010
Angina			2.0	0.001
Impaired Sensorium			1.4	0.020
Age 70-79 vs age < 50			1.7	0.003
Age 80-89 vs age < 50			2.0	<0.001
Age 90+ vs age < 50			2.4	<0.001
BMI 25-30 vs BMI <25			0.9	0.023
BMI 35+ vs BMI <25			1.2	0.030
Native American or Pacific Islander vs White race	2.6	0.042		
Male sex	1.2	0.038	1.2	<0.001
ASA 3 vs ASA 1-2	2.2	<0.001	1.8	<0.001
ASA 4+ vs ASA 1-2	3.6	<0.001	3.0	<0.001
Procedure type (vs percutaneous pinning)				
Hemiarthroplasty	1.5	0.005	1.5	<0.001
Primary total hip arthroplasty			1.6	<0.001
Plate/screw			1.3	0.009
Intramedullary nail	1.4	0.020	1.4	0.001

OR = odds ratio; BMI = body mass index; ASA = American Society of Anesthesiologists.