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The impact of resident involvement on outcomes in orthopedic trauma: An analysis of 20,090 cases

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ABSTRACT

Background: Involvement in patient care is critical in training orthopedic surgery residents for independent practice. As the focus on outcomes and quality measures intensifies, the impact of resident intraoperative involvement on patient outcomes will be increasingly scrutinized. We sought to determine the impact of residents' intraoperative participation on 30-day post-operative outcomes in the orthopedic trauma population.

Methods: A total of 20,090 patients from the American College of Surgeons National Surgical Quality Improvement Program database from 2006 to 2013 were identified. Patient demographics and comorbidities, surgical variables, and 30-day post-operative (wound, minor, and major) complications were collected. Chi-squared and analysis of variance statistical methods were used to compare the 30-day outcomes of patients with and without a resident's intraoperative involvement.

Results: Resident involvement had no effect in the incidence of wound and minor complications among all three anatomic sites of orthopedic trauma procedures (hip, lower extremity [LE], and upper extremity [UE]). There was no statistically significant difference in the incidence of major complications in the hip and LE groups. The UE group, however, demonstrated an increase in the rate of major complications (2.60% vs. 1.89%, $p = 0.046$). There was no difference in mortality or readmission rates.

Conclusions: Resident involvement in orthopedic trauma cases did not significantly impact the 30-day outcomes in nearly all domains. Our findings support continued resident involvement in the care of the orthopedic trauma patient.

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1. Introduction

Resident involvement in patient care is integral in training physicians for independent practice. In the case of the surgical

trainee, supervised participation in the operating room during operations is an irreplaceable facet of surgical training. Recently, resident participation has come under increased scrutiny as an area for improved efficiency and safety in patient care.^{1,2} As more emphasis is placed on outcomes and

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quality measures in the evolving healthcare system, the impact of orthopedic residents' involvement should be well defined.

The effect of residents' involvement on post-operative outcomes has been studied to varying degrees in both the orthopedic surgery and general surgery literature. Previous studies examining the effect of resident involvement in the field of general surgery have yielded mixed results, ranging from improved patient survival to increased patient mortality.^{3–11} Comparatively fewer studies have evaluated this effect in orthopedic trauma surgery, and to date, the results of these studies have shown no significant impact of residents' involvement on post-operative morbidity and mortality. The most recent studies utilizing the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) in orthopedics have demonstrated no difference in the complication rates when evaluating the effect of residents' involvement in total joint arthroplasty, arthroscopy, lower extremity (LE) trauma, and spine surgery.^{12–16}

To date, no study has looked at the impact of residents' intraoperative involvement in orthopedic trauma. Previous studies assessing the effect of residents' involvement in orthopedic surgery have evaluated cohorts composed largely of arthroplasty, spine, and arthroscopy patients. Notably, patients undergoing fracture fixation accounted for 3.9% to 15.1% of the total cohorts in these studies.^{12,15} With this in mind, we sought to define the impact of resident participation on 30-day outcomes following hip, lower extremity, and upper extremity fracture care.

2. Methods

2.1. Dataset

This study was performed in accordance with the relevant regulations of the US Health Insurance Portability and Accountability Act (HIPPA) and the ethical standards of the 1964 Declaration of Helsinki. The protocol was approved by the Vanderbilt Institution Review Board. Access to the (ACS-NSQIP) dataset between 2006 and 2013 was granted by the ACS-NSQIP. NSQIP is a program that prospectively collects and audits over 250 standardized data points on patient demographics, risk factors, laboratory values, operative variables, and postoperative events in a broad group of surgical specialty cases. Patients are monitored for thirty days post-operatively for complications, reoperations, or readmissions. The data are collected by trained surgical clinical reviewers (SCRs) using standard tools and definitions and then are entered into the NSQIP database, the collection of which has been shown to be more accurate than that of insurance claims. Participating institutions include over 400 public, private, academic and non-academic hospitals in a variety of settings.

2.2. Patient selection

Current Procedural Terminology (CPT) codes were used to query the NSQIP database and group specific surgical

procedures for comparison. The surgical procedures used in this study and their corresponding CPT codes are listed in [Appendix 1](#).

We collected and analyzed relevant surgical variables for each group. These included: age, American Society of Anesthesiologists' (ASA) classification, gender, race, body mass index (BMI), smoking status, functional status, medical comorbidities, and operative variables. Medical comorbidities included diabetes mellitus, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), dialysis, cancer, corticosteroid use, a recent history of unintended weight loss, dyspnea, or a bleeding disorder. Resident involvement in each case, in addition to their level of training, was also collected from the NSQIP database.

2.3. Outcomes

Complications were defined as surgical (wound), major medical, or minor medical. Surgical complications included: superficial and deep surgical site infections, wound dehiscence, graft/prosthesis/flap failure, and return to the operating room. Minor medical complications included: urinary tract infections, renal insufficiency, deep vein thrombosis, need for a blood transfusion, pneumonia, and peripheral nerve injury. Major medical complications included: pulmonary embolism (PE), prolonged ventilation (>48 h), unplanned intubation, acute renal failure (ARF), cardiac arrest, myocardial infarction (MI), stroke, coma (>24 h), organ space infections, sepsis, and septic shock.

Complication rates, mortality, operative time, length of stay, and rate of reoperation within 30 days were all calculated and compared among cohorts.

2.4. Statistical analysis

The demographics, comorbidities, operative time, length of stay, rate of reoperation, and complications were compared between the cohort with resident involvement and without resident involvement. Chi squared analysis was used for the categorical variables, and analysis of variables (ANOVA) was used to compare the continuous variables. Statistical significance was set at $p = 0.05$. Statistical programming was computed using the software Statistical Analysis System (SAS) 9.4 (SAS Institute Inc., Cary, NC, USA, 2013).

3. Results

A total of 20,090 patients met the inclusion criteria and underwent an orthopedic procedure designated by the CPT codes in [Appendix 1](#). Surgical procedures were then subcategorized into anatomic region of injury. The distribution among hip (Hip), LE, and upper extremity (UE) cases is shown in [Table 1](#). Overall, residents participated in 33.0% of all the operative trauma cases included in this analysis analyzed. If no resident was involved in the surgery, the operation was recorded as "Attending only." The demographics of each group are shown in [Table 2](#).

There were no significant differences in wound complications or minor complications among all three sites (Hip, LE, UE)

Table 1 – Breakdown of residents' intraoperative involvement in surgical cases.

	Lower extremity N = 7243	Upper extremity N = 5408	Hip N = 7439
Resident involved, N (%)	2493 (34.4)	1832 (33.9)	2314 (31.1)
Attending only, N (%)	4750 (65.6)	3576 (66.1)	5125 (68.9)

when comparing those with and without resident intraoperative involvement (Table 3). Concerning major complications, there was no statistically significant difference in the outcomes between the Hip and LE groups. Statistical significance was achieved in the UE group, and patients who underwent UE surgery with a residents' intraoperative involvement were more likely to experience a major complication (MI, PE, ARF, sepsis) than those without a resident's involvement ($p = 0.046$).

There was no difference in the mortality or readmission rate among all three sites between the cohort with and the cohort without resident involvement. Longer hospital length of stay was associated with resident involvement in hip cases (<0.0001). Resident participation did not affect length of stay in the LE or UE groups. In considering operative times, the cohort without residents' involvement had a shorter operative time among all three groups ($p \leq 0.0001$) (Table 3).

Table 3 – Postoperative outcomes.

	Site	Resident involvement		p-Value
		Yes	No	
Wound complications, %	Hip	0.60	0.50	0.60
	LE	0.72	0.77	0.79
	UE	0.11	0.17	0.72
Minor complication, %	Hip	9.95	9.94	0.068
	LE	4.26	3.99	0.59
	UE	1.63	1.39	0.80
Major complication, %	Hip	12.81	11.68	0.064
	LE	5.01	4.28	0.37
	UE	2.60	1.89	0.046
Mortality, %	Hip	6.15	7.33	0.06
	LE	1.35	1.27	0.78
	UE	0.70	0.56	0.58
Operative time, (min)	Hip	83.70	58.04	<.0001
	LE	105.32	78.36	<.0001
	UE	113.26	84.86	<.0001
Length of stay, (days)	Hip	7.64	5.67	<.0001
	LE	3.99	3.84	0.61
	UE	1.49	1.76	0.21
Readmission rate, %	Hip	10.33	11.03	0.66
	LE	5.86	5.85	0.99
	UE	2.51	2.47	0.99

When subdividing the resident cohort into junior resident, senior resident, or fellow resident, we found no statistical difference in the major or minor complications between the three resident groups. This was true for all

Table 2 – Patient demographics across the three operative sites.

Characteristic	Resident intraoperative involvement								
	Yes	No Hip	p-Value	Yes	No LE	p-value	Yes	No UE	p-Value
Demographics									
Age (years), mean	77.5	79.8	<.0001	52.9	54.9	<.0001	53.1	55.5	<.0001
Sex (% female)	67.6	71.6	0.0005	50.6	57.1	<.0001	58.2	63.1	0.0005
Race (% white)	65.5	84.1	<.0001	59.8	74.9	<.0001	61.1	77.2	<.0001
BMI (kg/m ²), mean	20.5	22.1	0.011	26.6	27.5	0.002	25.4	26.1	0.021
Comorbidities									
Smoking (% yes)	13.8	12.6	0.171	25.1	24.4	0.501	19.9	21.0	0.341
Functional status (% independent)	74.2	77.4	0.161	90.6	92.0	0.297	94.7	98.8	0.139
Diabetes	17.5	17.5	0.296	18.4	18.2	0.463	10.2	11.1	0.760
COPD	12.6	11.7	0.246	4.9	5.1	0.621	2.8	3.7	0.100
CHF	4.1	3.1	0.041	1.7	1.2	0.070	0.5	0.3	0.489
Steroid use	6.2	4.7	0.005	3.9	2.7	0.003	2.3	2.4	0.889
Dialysis	3.3	1.7	<.0001	2.4	2.1	0.271	0.6	0.6	1.000
Recent weight loss	2.3	1.62	0.055	1.1	0.4	0.0003	0.3	0.4	0.816
Bleeding disorder	17.4	15.6	0.058	6.0	6.2	0.738	3.2	3.4	0.704
Dyspnea	12.2	9.8	0.0002	6.2	5.7	0.409	4.0	4.6	0.325
Cancer diagnosis	4.4	2.4	<.0001	1.2	1.1	0.752	2.2	0.9	<.0001
Preoperative variables									
ASA 1	1.8	1.4	0.145	15.9	17.0	0.241	22.8	21.2	0.154
ASA 2	17.9	19.6	0.084	42.6	43.8	0.313	49.3	47.5	0.201
ASA 3	60.6	61.8	0.315	34.6	31.1	0.003	25.2	27.9	0.031
ASA 4	19.5	17.0	0.008	6.8	8.0	0.046	2.6	3.2	0.202

Table 4 – Resident comparisons across all three operative sites.

Site	Resident level	Minor complication	Major complication	All complications	Operative time
Hip (n = 1957)	Junior (596)	9.22%	11.58%	18.0%	77.96
	Senior (1127)	10.20%	13.84%	20.1%	89.38
	Fellow (248)	11.29%	10.88%	18.5%	89.99
	p-Value	0.62	0.26	0.45	<.0001
LE (n = 2272)	Junior (865)	4.97%	6.00%	8.6%	99.5
	Senior (1149)	3.92%	5.31%	7.9%	111.37
	Fellow (304)	4.60%	3.95%	8.2%	112.54
	p-Value	0.63	0.67	0.95	<.0001
UE (n = 1787)	Junior (515)	1.54%	3.65%	4.6%	111.17
	Senior (777)	1.67%	2.18%	3.2%	114.71
	Fellow (495)	1.88%	2.41%	3.8%	117.08
	p-Value	0.91	0.26	0.42	0.43

three operative sites (Table 4). There was a statistical difference in the operative times in the hip and LE operations. The hip and LE surgeries involving junior level residents were shorter than those with senior level residents or fellows ($p < 0.0001$). No statistically significant difference was present in the operative times of UE cases among the three resident groups ($p = 0.43$).

4. Discussion

In patients who underwent operative fixation of UE, LE, and hip fractures, we found resident involvement was not an independent risk factor for complications (wound, major, minor) in nearly all domains. We found a small increase in the incidence of major complications in patients undergoing UE surgery with a resident involved in their care. Notably, the UE operations included in the analysis (distal radius, proximal humerus, and clavicle fractures) are unlikely to play a significant role in the occurrence of these major complications (PE, prolonged ventilation (>48 h), unplanned intubation, ARF, MI, stroke, coma (>24 h), organ space infections, sepsis). The significance of this finding is unclear given the major complications noted above are all medical in nature. The occurrence of a major medical complication is a reflection on perioperative, rather than intraoperative, management. This highlights a limitation of the NSQIP database, which does not include any information on resident care during the perioperative period.

Operative times were longer with residents' intraoperative involvement among all surgical site groups (see Table 3 for attending operative time). Interestingly, surgeries with a junior level residents' involvement had a significantly shorter operative time across all three surgical sites than those with a senior resident or fellow (Table 4). This difference may derive from an increased level of involvement and oversight from attendees at the junior residents' level leading to decreased operative times. On the other hand, senior level residents and fellows are given more opportunity to operate independently, leading to their increased times. This is typical in the orthopedic residency

programs in the United States that follow a graduated responsibility curriculum. We also found that the resident training level did not have a significant effect on 30-day complication rates.

This study has several limitations. The ACS-NSQIP database tracks a patient for thirty days following their index operation and patient long-term follow-up is lost. Also, NSQIP currently only records resident intraoperative involvement at this time; therefore, residents' involvement preoperatively and postoperatively is unable to be assessed and may influence postoperative outcomes, as previously discussed. Large database studies have inherent weaknesses as well. In this study, differences in case complexity are unable to be accounted for, as is the degree of residents' participation during surgery.

As increasing emphasis is placed on quality measures in patient care and outcomes reporting, this study adds to the growing literature in orthopedic surgery reporting similar outcomes in patients with a resident involved in their care. Training in orthopedic trauma is critical in educating the orthopedic resident in the fundamentals of fracture care. As residency training continues to undergo changes, our study supports this mutually beneficial relationship between residents and orthopedic trauma patients.

Conflicts of interest

Author William Obremskey has previously consulted for biometrics; done expert testimony in legal matters, and has received a grant from the Department of Defense. For the remaining authors, no conflicts of interest were declared.

Ethical review committee statement

This study was performed in accordance with the relevant regulations of the US Health Insurance Portability and Accountability Act (HIPPA) and the ethical standards of the 1964 Declaration of Helsinki. The protocol was approved by the Vanderbilt Institution Review Board.

Appendix 1. Orthopedic Trauma CPT Codes

CPT	Procedure
HIP	
27235	Percutaneous skeletal fixation of femoral fracture, proximal end, neck
27236	Open treatment of femoral fracture, proximal end, neck, internal fixation or prosthetic replacement
27244	Open treatment of intertrochanteric, peritrochanteric, or subtrochanteric femoral fracture
27245	Treatment of intertrochanteric, peritrochanteric, or subtrochanteric femoral fracture, with intramedullary implant
LE	
27506	Open treatment of femoral shaft fracture, with or without external fixation, with insertion of intramedullary implant, with or without cerclage and/or locking screws
27759	Treatment of tibial shaft fracture (with or without fibular fracture) by intramedullary implant, with or without interlocking screws and/or cerclage
27792	Open treatment of distal fibular fracture (lateral malleolus), with or without internal or external fixation
27814	Open treatment of bimalleolar ankle fracture, with or without internal or external fixation
27822	Open treatment of trimalleolar ankle fracture, with or without internal or external fixation, medial and/or lateral malleolus; without fixation of posterior lip
UE	
23515	Open treatment of clavicular fracture, with or without internal or external fixation
23615	Open treatment of proximal humeral (surgical or anatomical neck) fracture, with or without internal or external fixation, with or without repair of tuberosity(s)
25607	Open treatment of distal radial extra-articular fracture or epiphyseal separation, with internal fixation
25608	Open treatment of distal radial intra-articular fracture or epiphyseal separation; with internal fixation
25609	Open treatment of distal radial intra-articular fracture or epiphyseal separation; with internal fixation of 3 or more fragments

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