

Original Research Article

Resident involvement in upper extremity fracture fixation impacts surgical time and hospital stay

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ABSTRACT

Background: The purpose of this study was to evaluate the impact of resident post graduate year (PGY) on surgical outcomes and operative time for upper extremity fracture fixation and associated complications.

Methods: Using the American college of surgeons' national surgical quality improvement program (NSQIP) database, we conducted a query for all upper extremity fracture cases using current procedural terminology (CPT) codes outlined by the ACGME requirements for orthopaedic resident education. A total of 2,853 patients met inclusion criteria based on our initial query. Surgical complications and operative times were analyzed based on resident participation and PGY level. Linear regression models were used to assess the impact of resident training level on case duration and patient time in the OR.

Results: Average total operative duration was significantly longer in cases with residents compared to cases without (average operative duration was 86.57 without a resident compared to 116.21 with resident(s), $p < 0.001$). As PGY year increased, operative case duration also increased. Calculations of change in operative duration per PGY year. Proximal humerus fractures 9.975-minute increase per year ($p = 0.042$); Humeral Shaft Fractures 9.933-minute increase per year ($p = 0.023$); elbow 7.558-minute increase ($p = 0.011$); distal radius 2.969-minute increase per year ($p = 0.038$). Resident involvement was also associated with an increased risk for intraoperative transfusions ($p = 0.019$) but not with any other surgical complications.

Conclusions: For upper extremity fractures, there was a predictable increase in total operative time as PGY year increased. Resident involvement led to increased operative duration and patient time in the operating room.

Keywords: Education, Resident, Trauma, Training, Upper extremity

INTRODUCTION

Training of surgical residents, has followed the same general structure for over a century. While modified slightly, following the advent of duty hours and accounting for a shift towards work-life balance and competency-based advancement, the basic model remains largely unchanged. In this current framework, residents experience graduated autonomy based on competency in each successive year of training. However, this apprenticeship model does not always yield upper level or chief residents who are fully confident in their skills. A

2013 survey of general surgery residents found that only 23% of graduating residents felt a general surgery residency fully prepares residents for independent practice.¹ Another 2019 survey of post-graduate year (PGY) 4 and PGY 5 general surgery residents found low confidence rates in a number of abdominal wall procedures (such as hernia repairs).² There has also been a recent decline in operative autonomy of surgical residents and trainees.^{3,4} This has been demonstrated by two Veterans Affairs Surgical Quality Improvement Program (VASQIP) database studies both spanning a 15-years period between 2004 and 2019. In the first, all surgical cases were

included. The percentage of attending primary cases almost doubled from 16.8% to 31%, while the percentage of resident primary cases was reduced from 16.1% in 2004 to just 6.1% by 2019.³ These findings were supported by a similar study that focused only on general and vascular surgery patients.⁴ In this study, the number of resident primary and attending primary cases decreased and increased respectively by similar factors as noted above.⁴ This observed decrease in surgical resident autonomy may be playing a role in the reduced confidence of upper-level residents and increased utilization of fellowships in surgical subspecialties.⁵

Many factors influence resident autonomy in the operating room. These can range from individual resident experience and abilities, attending comfort with the procedure or even systems factor such as time constraints.⁶ This problem is likely to persist as surgical reimbursements drop and larger caseloads are required to maintain fiscal stability.⁷ There is significant evidence, in both the orthopedic literature and in other surgical subspecialties, to suggest resident involvement increases operative duration.^{3,4,8-19} There is also some data to suggest an increase in cost associated with resident training, however, this data is mixed.^{16,17}

Coupled with the pressure to complete more cases in a shorter amount of time, the documented increase in case duration associated with resident involvement could lead to a shift towards attending primary cases (as noted above) and thus a decrease in resident involvement. Alternatively, other factors may also be contributing to decreased resident autonomy. Some studies have focused on attending comfort level with the procedure being performed as the driving factor for limiting resident autonomy with decreased comfort on the part of the attending being associated with reduced resident autonomy.⁶ Both factors provide a potential explanation for the documented decrease in chief resident confidence noted above.

Given the decrease in senior resident confidence levels, there is a significant need to better understand the factors contributing to decreased resident autonomy. While there is evidence to support the increase in case duration with resident involvement, most literature focuses on the binary presence or absence of residents in surgical cases and do not investigate differences among different levels of training. Nor do these studies show how these differences could impact case duration.

Similarly, while there is strong evidence to suggest that resident involvement does not result in significant complications, some studies suggest resident involvement may increase morbidity and minor complications.^{14,15,20-23} Thus, we set out to evaluate the impact of resident PGY level on both surgical outcomes and operative time for upper extremity fracture fixation using the American College of Surgeons National Surgical Improvement Program (NSQIP) database. We hypothesized that increasing year of training would result in an increase in

total operative time as resident autonomy increases with each successive year.

METHODS

Using the American College of Surgeons' National Surgical Quality Improvement Program (NSQIP) database, we conducted a retrospective analysis of all upper extremity fractures from 2005-2020. A query was created using current procedural terminology (CPT) codes from the Accreditation Council for Graduate Medical Education (ACGME) Case Log Guidelines for Orthopedic Trauma in order to capture all cases of upper extremity fractures 24. This database uses information gathered from more than 600 participating hospitals across the U.S. and captures information regarding patient demographics, comorbidities, diagnoses, surgeries, procedures and complications (out to 30 days). Data are deidentified and shared with all participating institutions.

Using specific CPT codes acquired from the ACGME Guidelines we identified cases for several fracture locations including proximal humerus, humeral shaft, radial head/proximal ulna and distal radius (Table 4). Additionally, we only included cases that had documented resident involvement (NSQIP defines resident involvement as resident who scrubbed in for the procedure). We identified a total of 2853 patients who met inclusion criteria. We gathered demographic data on the cohort including age, BMI category, gender, ASA score, smoking status and race, all of which are shown below in table 1. Resident involvement, in surgical fixation by PGY year was also obtained through this database and is shown based on fracture location in table 2. PGY 1-5 were assumed to be orthopaedic categorical residents and PGY 6 was assumed to be orthopaedic fellows. We excluded patients that did not have available data regarding resident involvement.

Authors first conducted covariate analyses using a Chi-square to determine any significant associations between resident involvement and any surgical complication. Any significant associations were then further evaluated with multivariate regression to limit the influence of patient comorbidities and preoperative surgical risks. Independent samples t-test was used to determine any significant differences in operative duration between groups.

Based on the specific location of the fracture, we conducted a linear regression analysis to create predictive models for surgical time by PGY year and resident involvement compared to no resident involvement. All data was analyzed using IBM SPSS statistical software for Windows, version 28 (Armonk, NY, USA). Alpha was set to .05 for all analyses.

RESULTS

Patient demographics for the 2853 patients who met inclusion criteria are shown in Table 1. We found a

significant association between resident involvement and some surgical complications, including intraoperative transfusions ($p=0.022$). To control for possible confounders, we conducted multivariate regression analyses which showed a persistent association between resident involvement and risk of intraoperative transfusions ($p=0.019$) but not aggregated surgical complications ($p=0.166$).

Average total operative duration was significantly longer in cases with residents compared to cases without (average operative time with resident 116.21 minutes; average operative time without resident 86.57, $p<0.001$). Results of a regression analysis comparing the involvement of residents versus no residents predicted an increase in operative duration of 25.896 minutes (with a baseline of

90.53, $p\text{ value}<0.001$) based on the estimates from cases included in this cohort.

We found that as PGY year increased, operative duration also increased. Using linear regression modeling, we created predictive equations for change in operative duration per PGY year based on location. The increase differed for each location: Proximal humerus fractures 9.975 minutes increase per year ($p=0.042$). Humeral shaft fractures 9.933 minutes increase per year ($p=0.023$). Elbow 7.558 minutes increase per year ($p=0.011$). Distal radius 2.969 minutes increase per year ($p=0.038$). When analyzed across all fracture sites, the increase in operative time was predicted to be 4.831 minutes per PGY year increase ($p<0.001$) (Table 3). We also found a similar 3.852 minutes increase in duration of patient in room for every PGY year increase ($p=0.004$).

Table 1: Demographics of patients who met inclusion criteria (n=2853).

Demographic data		N	%
Age (in years)	<18	3	0.1
	18-39	474	16.6
	40-64	1287	45.1
	65-74	556	19.5
	>75	534	18.7
BMI	<18.5	3	0.1
	18.6-24.9	474	16.6
	25-29.9	1287	45.1
	30-34.9	556	19.5
	35-39.9	534	18.7
Gender	Male	916	32.1
	Female	1929	67.6
ASA score	1	431	15.1
	2	1461	51.2
	3	961	33.7
	4	0	0.0
Smoking status	No	2282	80.0
	Yes	571	20.0
Race	White	114	4.0
	Black	3	0.1
	Hispanic	6	0.2
	Other	2730	95.7

Table 2: Frequency of resident involvement in all upper extremity fracture cases by PGY level.

PGY year	Proximal humerus	Humeral shaft	Radial head and/or proximal ulna shaft	Distal radius
1	9	5	4	25
2	26	17	21	54
3	44	23	31	117
4	52	31	51	132
5	51	38	56	145
6	28	24	35	118
Total	210	138	198	591

Table 3: Predictive equation for increase in operative time by resident year.

Fracture location	Increase in operative time per PGY year
Proximal humerus	110.864+(9.975×PGY Year)
Humeral shaft	110.984+(9.933×PGY Year)
Radial head and/or proximal ulna shaft	79.219+(7.56×PGY Year)
Distal radius	87.142+(2.97×PGY Year)
All sites	96.355+(4.831×PGY Year)

Table 4: CPT codes for upper extremity fracture procedures.

CPT codes	
Proximal humerus fractures	
23615	Open reduction and internal fixation of proximal humeral fracture
23616	Open treatment of proximal humeral fracture with proximal humeral prosthetic replacement
Humeral shaft fractures	
24515	Open treatment of humeral shaft fracture with plate and screw fixation
24516	Treatment of humeral shaft fracture with insertion of intramedullary implant
Radial head and/or proximal ulna fracture	
24665	Open treatment of radial head or neck fracture
24666	Open treatment of radial head or neck fracture with prosthetic replacement
24685	Open treatment of proximal ulna fracture (including olecranon or coronoid process)
Distal radius fracture	
25606	Percutaneous skeletal fixation of distal radial fracture
25607	Open treatment of distal radius fracture: extra-articular
25608	Open treatment of distal radius fracture: intra-articular 2 fragments
25609	Open treatment of distal radius fracture: intra-articular 3 fragments

DISCUSSION

Our results clearly demonstrate an association between resident involvement and increased operative duration. While this is not surprising given the abundance of data showing an association between resident involvement and operative duration, we are limited in our ability to draw conclusions without more information on the nature of the sites involved in the data collection. Despite this limitation, however, we were able to model this increase in case duration per PGY year and predict the time each successive PGY year adds to cases-both overall for upper extremity fractures and for at specific locations. It has been shown previously that resident involvement could increase overall operative time.^{3,4,8-19} However, only one other study has shown a predictable increase based on PGY year 14 and this was only for lower extremity fractures.

To our knowledge, no other study has demonstrated a predictable increase in operative time by PGY year for upper extremity fractures. Increased participation for residents at higher PGY levels may help explain the incremental rise in case duration as upper-level residents are often more involved. Indeed, this explanation provides a plausible explanation for the modeled trend as the new model of surgical training favors more resident involvement with increased competency. Another reason for this increase may be related to increased exposure to

complex cases or less direct attending supervision during parts of the case—such as the approach. While mastery comes with repetition, upper-level resident involvement in surgical cases likely leads to an increase in operative time due to their advancement in skill and thus trust from their mentor in performing more complex portions of the case. It follows, then that our data also demonstrated a significant increase in patient time in the operating room in cases involving residents.

While all surgical complications did not remain significant with multivariate regression, our results of minor complications being associated with resident involvement are consistent with several prior studies.^{8,10,13,14} It may be that the increase in operative duration is related to the increase in transfusion requirements. Increased surgical duration has been shown to be associated with higher complications, regardless of resident involvement.²⁵

This is the first study to examine resident involvement in upper extremity fractures and the subsequent impact on case duration. A study by Traven et al, similarly evaluated the effect of PGY level on operative duration for lower extremity fractures.¹⁴ This lower extremity study demonstrated a similar increase in operative time per PGY level, however, the times noted in our study were all of greater magnitude. Additionally, they found some increase in wound infections and wound dehiscence when analyzed

by PGY level.¹⁴ However, we did not find an association with either in our analysis. The study begins to address one of the many variables impacting resident autonomy and surgical training. While the increase in case duration associated with resident involvement still poses a major barrier to resident training, better characterization of the time each PGY year adds to a case is one step in the direction of mitigating this factor as a barrier. Clearly, the training of the next generation of surgeons is of the utmost public interest. This goal is increasingly challenging in light of changes in physician practices towards a hospital-employed model with increasing hospital reimbursement and stable or decreasing physician reimbursement and increasing reimbursements for primary care or office-based practices.^{7,26,27} This study along with many others have demonstrated the safety of the current model for training of surgical residents.²⁰⁻²³

Despite its imperfections, the safety of this system has been widely adopted across the US and persisted for many years. Unfortunately, due to a combination of above outlined factors surgeons are required to carry increased caseloads which directly opposes the goals of adequately training surgical residents. As such, it is imperative that legislators, hospital administrators and graduate medical education officials begin to work towards a solution and our paper provides key information to forming new solutions. Some of the potential remedies include working towards direct billing for the assisting services of resident physicians to offset the indirect costs and lost opportunity cost to physicians of their participation. This is not dissimilar from training in primary care where residents are allowed to bill for limited services rendered under the “Medicaid primary care exception rule”.^{28,29}

This rule, which has been in place for many years and is continuously updated and modified, incentivizes resident autonomy by allowing residents to bill for services rendered without the direct supervision of an attending physician.^{28,29} While it is not without critique, a model such as this could provide a possible solution for increasing surgical resident autonomy by removing some of the need for OR efficiency. For example, in small or routine cases that are ‘resident primary,’ surgical residents would be able to bill for the operation, even in the absence of direct attending oversight. This would free-up the attending to focus on more complex cases while still allowing residents the opportunity to gain experience. Alternatively, stipends for attendings who participate in the training of residents could help compensate for the increased OR time required for resident training. Both would help facilitate resident learning in an increasingly lean and efficiency-driven healthcare model.

As with all database studies, we are limited by the accuracy of the data as individual hospitals may have slightly different reporting protocols. We are also limited in the minimal outcome data available through NSQIP. NSQIP offers no information as to the complexity of cases included in the dataset. Additionally, our dataset was

constrained by the need to include cases with documented resident involvement – this proved to lower our number of cases substantially, but not so far as to compromise the significance of our models. However, this may limit the external validity of our results. Lastly, NSQIP is a hospital-based dataset and may miss some cases of upper extremity care as many of these cases are done on an outpatient basis.

CONCLUSION

Using data from the NSQIP database, we found a predictable increase in case duration with each successive PGY year for several different fracture locations in the upper extremity. These findings are consistent with prior studies demonstrating increased operative duration with resident involvement but add to the current body of literature by addressing the impact of individual PGY year on operative time. We also found a significant association between resident involvement and intraoperative transfusions, but no association between resident involvement and aggregate surgical complications. In the setting of decreased reimbursement for surgical procedures, we must incentivize resident involvement in care of patients and ensure that we are not inadvertently further disincentivizing resident education through changes in reimbursement. This is of critical importance in all surgical subspecialties and particularly orthopaedics.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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