The Impact of Resident Involvement on Patient Outcomes in Revision Total Hip Arthroplasty

O impacto do envolvimento do residente nos resultados dos pacientes na revisão da artroplastia total do quadril

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Abstract

Objective The aim of the present study was to determine the influence of resident involvement on acute complication rates in revision total hip arthroplasty (THA).

Methods Using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, 1,743 revision THAs were identified from 2008 to 2012; 949 of them involved a resident physician. Demographic information including gender and race, comorbidities including lung disease, heart disease and diabetes, operative time, length of stay, and acute postoperative complications within 30 days were analyzed.

Results Resident involvement was not associated with a significant increase in the risk of acute complications. Total operative time demonstrated a statistically significant association with the involvement of a resident (161.35 minutes with resident present, 135.07 minutes without resident; $p < 0.001$). There was no evidence that resident involvement was associated with a longer hospital stay (5.61 days with resident present, 5.22 days without resident; $p = 0.46$).

Conclusion Involvement of an orthopedic resident during revision THA does not appear to increase short-term postoperative complication rates, despite a significant increase in operative times.

Keywords
- internship and residency
- arthroplasty, replacement, hip
- orthopedic procedures
- postoperative complications

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Resumo

Objetivo O objetivo do presente estudo foi determinar a influência do envolvimento dos residentes nas taxas de complicações agudas na revisão da artroplastia total do quadril (ATQ).

Métodos Utilizando o banco de dados do American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP, na sigla em inglês), foram identificadas 1.743 revisões de ATQs entre 2008 e 2012; 949 delas envolveram um médico residente. Foram analisadas informações demográficas, incluindo gênero e raça, comorbidades, incluindo doenças pulmonares, doenças cardíacas e diabetes, tempo de permanência e complicações agudas pós-operatórias no prazo de 30 dias.

Resultados O envolvimento dos residentes não foi associado a um aumento significativo no risco de complicações agudas. O tempo de operação total demonstrou associação estatisticamente significativa com o envolvimento de um residente (161,35 minutos com residente presente, 135,07 minutos sem residente; $p < 0{,}001$). Não houve evidência de que o envolvimento do residente tenha sido associado a um maior tempo de internação hospitalar (5,61 dias com residente presente, 5,22 dias sem residente; $p = 0{,}46$).

Conclusão O envolvimento de um residente ortopédico durante a revisão da ATQ não parece aumentar as taxas de complicações pós-operatórias de curto prazo, apesar de um aumento significativo nos tempos operacionais.

Palavras-chave

- internato e residência
- artroplastia de quadril
- procedimentos ortopédicos
- complicações pós-operatórias

Introduction

In 2010, nearly 7 million individuals lived with an artificial hip or knee in the United States.[1] This number is expected to rise as total hip arthroplasty (THA) utilization rates increase secondarily to a rise in the elderly population and life expectancy.[2] By 2030, the demand for primary THA is estimated to reach 572,000 per year, or 174% of the current rate.[3] As the total number of primary THA procedures performed increases, the number of revision surgeries also stands to increase significantly. In one projection, revision THA procedures will increase 2-fold by 2026.[3]

If the numbers for both primary and revision THA grow as projected, the estimated number of THA cases will surpass the estimated amount of fellowship-trained arthroplasty surgeons.[3,4] As a result, non-fellowship trained surgeons will experience increased demand to perform primary and revision THA, requiring them to rely on the skills and techniques developed during residency.[5] Therefore, residents must be provided with high-quality training in performing both primary and revision total hip arthroplasty.

Healthcare systems are becoming increasingly more attentive to postoperative morbidity and mortality, as complications may decrease the quality of life of a patient and increase the financial burden on hospitals and healthcare providers.[2] As a result, healthcare systems are implementing quality control initiatives.[6] Residents comprise a large fraction of the healthcare team within academic centers. and quantifying their impact on acute postoperative complications is imperative. In general surgery, considerable amounts of literature have tried to quantify whether resident involvement exerts any detrimental effects on the outcomes of surgical procedures, but studies have varying results.[7–10] Similar literature for orthopedics is not nearly as vast.[11–15]

The objective of the present study was to determine the impact of resident involvement in revision THA using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database.[16] Perioperative and postoperative complication rates for revision THA cases with resident involvement were analyzed to discern whether resident involvement is correlated with poor patient outcomes.

Materials and Methods

The National Surgical Quality Improvement Program (NSQIP) was established in 2012 to help better understand and improve patient outcomes. Clinical information and surgical outcomes were collected from > 400 hospitals in 2012. The variety of hospitals sampled included private, public, academic, and nonacademic hospitals in both urban and rural areas. Patients are followed for 30 days after surgery, and any acute complications, reoperations, or readmissions are recorded. The database is maintained by the American College of Surgeons and the data are collected by a trained surgical clinical reviewer.

Patient Selection

Patients included in the present retrospective observational study had a THA revision defined by the Current Procedural Terminology code 27134 (repair, revision, and/or reconstruction procedures on the pelvis and hip joint) between 2008 and 2012. The NSQIP records resident involvement using the variable "PGY" followed by a number (1 to 6), which

identifies the year of residency training. The resident surgeon who was scrubbed in and has the highest level of training was recorded. Cases that do not include a resident were recorded with a "0." Resident levels PGY1–5 were included, while fellows (PGY6) were excluded. In addition, if resident involvement was not indicated, the patient was excluded. The extent of resident participation in the case was not explicitly stated in NSQIP, but the level of training was included. In total, 1,743 patients underwent revision THA and met the inclusion criteria. Of these, 54.4% ($n = 949$) were performed with resident involvement.

Outcomes

The acute postoperative complications identified within 30 days include graft/prosthesis/flap failure, surgical site infection, wound dehiscence, reoperation, pneumonia, unplanned intubation, deep vein thrombosis (DVT), pulmonary embolism (PE), ventilation > 48 hours, renal insufficiency, acute renal failure, urinary tract infection (UTI), stroke/cerebrovascular accident (CVA), peripheral nerve injury, cardiac arrest, and myocardial infarction. Total operative time and length of hospital stay were also analyzed.

Statistical Analysis

Preoperative demographic, medical comorbidities and postoperative outcomes were compared between cases with and without resident involvement using the two-sided chi-squared test and the Fisher exact test. Variables related to operative time were adjusted using a multivariable linear regression to remove their potentially confounding influence on the association between operative time and resident involvement. All p-values ≤ 0.05 were considered statistically significant.

All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, North Carolina).

Results

Preoperative Characteristics

Preoperative characteristics stratified according to resident involvement are shown in ►**Table 1**. Variables showing significance include type of anesthesia ($p < 0.001$), chronic obstructive pulmonary disease (4.64% resident present, 6.93% no resident; $p = 0.04$), prior operation within 30 days (3.79% resident present, 6.52% no resident; $p = 0.01$), hypertension requiring medication (55.53% resident present, 63.98% no resident; $p < 0.001$), diabetes status ($p = 0.005$), and inpatient status (98.10% resident present, 99.37% no resident; $p = 0.02$).

Total Operative Time and Length of Stay

Univariate comparisons of complication rates between revision THA procedures with and without the involvement of a resident are shown in ►**Table 2**. There was a significant increase in total operative time with resident involvement versus without resident involvement (161.35 minutes resident present, 135.07 minutes no resident; $p < 0.001$). Length of stay (in days) was not significantly increased (5.61 days resident present, 5.22 days no resident; $p = 0.46$).

Acute Postoperative Complications

Most complication rates decreased with a resident present, although they did not reach significance.

Multivariable Regression Model and Risk Factors

Significant results from the regression model for operative times are shown in ►**Table 3**. Operative times increased by 28.41 minutes with resident involvement ($p < 0.001$). Patients identifying as black or African American had longer operation times (+10.79 minutes; $p = 0.02$).

Variables showing shorter operative times included female patients, an ASA classification of 1 or 2, previous percutaneous coronary intervention (PCI), prior operation within 30 days of THA, being an active smoker, and outpatient status. Surgeries that used spinal or regional anesthesia were significantly shorter than surgeries using the other anesthesia types. (- 19.94 minutes and - 38.471 minutes, respectively; $p < 0.001$ for both).

Power Analysis

For all the comparisons except operating room time, the power is < 10%. The power for operating room time is 99%.

Discussion

Resident involvement in revision total hip arthroplasty does not significantly increase acute postoperative complications within 30 days. This large national database study of 1,743 cases found that operative time increased an average of 28.41 minutes. Despite this increase in operation time, the number of acute postoperative complications was low in both patient cohorts. This highlights the general safety and efficacy of revision hip arthroplasty procedures. The increase in operative time seen with resident participation did not lead to an associated increase in superficial infections (0.95 versus 1.39%), deep infections (0.46 versus 0.93%), or wound dehiscence (0.42 versus 0.63%).

The numbers of both primary and revision THA cases are expected to surpass the estimated number of total fellowship-trained joint surgeons.[4] As this occurs, non-fellowship trained orthopedic surgeons will be encouraged to shoulder the extra demand, if they are adequately trained, highlighting the value of involving residents in revision hip arthroplasty cases. It is important, then, to understand the impact they have on patient outcomes. Residents do not influence complication rates in primary THA,[5,15] but revision THA is more complex and presents different challenges with new opportunities for complications.

Previous Studies on Resident Involvement

Major morbidity did not rise with resident involvement in 66,817 cases involving 6 different orthopedic procedures (stratifying for the severity of morbidity).[17] The influence of residents on minor morbidity, however, is difficult to isolate because of the high disease burden in patients and of the involvement of numerous staff postoperatively. The NSQIP data from 2005 to 2010 revealed that residents significantly increase the risk of ≥ 1 postoperative complications or major

Table 1 Preoperative Demographics and Medical Comorbidities Stratified by Resident Involvement for 1,743 Patients who had a Revision Total Hip Arthroplasty Recorded in the NSQIP Database from 2008–2012

	Resident present, %	Resident not present, %	*p-value*
Gender			
Female	54.12	52.33	0.46
Male	45.88	47.67	
ASA Classification			
ASA 1	1.48	1.89	0.51
ASA 2	43.20	39.80	
ASA 3	50.47	53.53	
ASA 4	4.74	4.79	
ASA 5	0.11	0	
Race			
American Indian or Alaska Native	0.65	0.41	0.78
Asian	1.04	0.55	
Black or African American	6.61	6.05	
Native Hawaiian or Pacific Islander	0.13	0.14	
White	91.58	92.85	
Anesthesia			
Epidural	0.21	1.01	< 0.001
General	74.71	73.17	
Conscious/Intravenous sedation	0.53	0	
Monitored anesthesia care	0.11	0.13	
Regional	8.96	1.89	
Spinal	15.28	23.80	
Unknown	0.21	0	
Chronic obstructive pulmonary disease	4.64	6.93	0.04
Congestive heart failure within 30 days before surgery	0.74	0.88	0.79
History of myocardial infarction 6 months prior to surgery	0.53	0.26	0.46
History of angina in 1 month before surgery	0.63	0.39	0.52
Acute renal failure, post-operatively	0.11	0.25	0.59
Previous percutaneous coronary intervention	7.17	7.47	0.85
EtOH $>$ 2 drinks/day in 2 weeks before admission	4.11	3.22	0.37
Previous cardiac surgery	6.32	6.57	0.84
History of revascularization/amputation for peripheral vascular disease	0.53	1.29	0.11
Currently on dialysis, pre-operatively	0.32	0.63	0.48
History of transient ischemic attacks	3.37	3.48	0.89
Cerebrovascular accident/stroke with neurological deficit	2.32	2.19	> 0.99
Cerebrovascular accident/stroke with no neurological deficit	3.07	3.22	0.89
Paraplegia	0.32	0.26	> 0.99
Hemiplegia	0.95	0.64	0.59
Quadriplegia	0.21	0	0.50

Table 1 (*Continued*)

	Resident present, %	Resident not present, %	*p-value*
Chemotherapy for malignancy in $\leq$ 30 days before revision total hip arthroplasty	0.53	0.39	0.73
Disseminated cancer	0.42	1.01	0.15
Steroid use for chronic condition	6.22	4.53	0.13
$>$ 10% loss body weight in last 6 months	0.63	1.26	0.21
Bleeding disorders	5.90	6.05	0.91
Prior operation within 30 days	3.79	6.52	0.01
Hypertension requiring medication	55.53	63.98	$<$ 0.001
Current smoker within 1 year	15.38	14.74	0.73
Diabetes Status			
Diabetes mellitus with insulin	3.37	3.78	0.005
Diabetes mellitus without oral agents or insulin	87.46	87.15	
Diabetes mellitus with non-oral and non-insulin agents	6.95	4.41	
Diabetes mellitus with oral agents	2.21	4.66	
Functional health status prior to surgery			
Independent	85.46	84.13	0.08
Partially dependent	13.49	13.22	
Totally dependent	1.05	2.52	
Unknown	0	0.13	
Inpatient	98.10	99.37	0.02

Abbreviation: ASA, American Society of Anesthesiologists.

systemic complications in total knee and hip joint arthroplasty.[11] This study did not stratify total knee and THA cases into separate cohorts. In contrast, a second study revealed that residents do not influence complications in primary THA cases, but revision surgeries were excluded in the analysis (NSQIP data from 2012).[5] Since revision THAs are more demanding procedures, data limited to primary THA procedures fail to accurately categorize resident involvement in revisions.[18–20] The present study did not evidence an increase in major or minor complications with the involvement of residents during revision THA cases.

Challenges of Revision THA

Primary THAs reliably reduce pain and increase functional status for patients with end-stage osteoarthritis. Through early operative intervention, patients can achieve excellent outcomes, and the rate of revision surgery remains low at 6% at 5 years and 12% at 10 years.[21,22] Despite the high success rates and benefits of primary THA, dislocation and infection may still lead to implant failure and revision.[4] The distorted anatomy and complications associated with primary THA can create unique challenges for orthopedic surgeons during revision.[20,23,24] These challenges can lead to an increased mortality, infection, and dislocation rates postoperatively in revision cases compared with primary THA.[25] Furthermore, patients undergoing revision THA have bone and soft tissue damage around the hip, which compromises the joint and often inhibits the use of standard primary implants.[20,23,24] It is crucial that surgeons are trained and competent when using specific implants designed to work effectively under poor conditions.

Effects of Resident Involvement

The present study showed that complication rates such as reoperation, DVT, and unplanned intubation decreased with residents involved in revision THA. The most common cause of failure for revision THA, infection (including superficial infections, deep infections, and wound dehiscence),[26] declined when residents were involved. Furthermore, the involvement of residents can help to increase their confidence and preparedness as they progress through their career.[27]

Despite complication rates not increasing significantly with resident involvement, there was a significant increase in operative time with resident involvement. This may stem from the challenge of teaching trainees on complicated anatomy, especially seen in patients with higher rates of comorbidities. This finding has been previously highlighted in general surgery and other surgical specialties.[28,29] Although increases in operation time do increase the risk of infection in primary joint arthroplasty,[30] the involvement of residents did not result in increased infections.

As expected, lower risk patients with less comorbidities, ASA classifications 1 and 2 and outpatient procedures, were

Table 2 Complication Rates, Length of Stay, and Total Operative Time Stratified by Resident Involvement for 1,743 Patients who had a Revision Total Hip Arthroplasty Recorded in the NSQIP Database from 2008–2012

	Resident present ($n = 949$)	Resident not present ($n = 794$)	*p-value*
Operative time, minutes	161.35	135.07	< 0.001
Length of stay, days	5.61	5.22	0.46
Acute postoperative complications, *n* (%)			
Graft/Prosthesis/Flap Failure	5 (0.53)	4 (0.50)	> 0.99
Superficial infection	9 (0.95)	11 (1.39)	0.49
Deep infection	12 (1.26)	16 (2.02)	0.25
Wound dehiscence	4 (0.42)	5 (0.63)	0.73
Reoperation	61 (6.43)	58 (7.30)	0.50
Pneumonia	4 (0.42)	6 (0.76)	0.52
Unplanned intubation	6 (0.63)	7 (0.88)	0.58
Deep vein thrombosis	7 (0.74)	7 (0.88)	0.79
Pulmonary embolism	1 (0.11)	1 (0.13)	> 0.99
Ventilation $>$ 48 hours	4 (0.42)	5 (0.63)	0 0.73
Renal insufficiency	3 (0.32)	2 (0.25)	> 0.99
Acute renal failure	2 (0.21)	2 (0.25)	> 0.99
Urinary tract infection	19 (2.00)	16 (2.02)	> 0.99
Stroke/Cerebrovascular Accident	2 (0.21)	4 (0.50)	0.42
Peripheral nerve injury	6 (0.63)	4 (0.50)	0.76
Cardiac arrest	3 (0.32)	4 (0.50)	0.70
Myocardial infarction	9 (0.95)	5 (0.63)	0.59

Table 3 Multivate Regression Analysis with Total Operative Time as the Dependent Variable for 1,743 Patients who had a Revision Total Hip Arthroplasty Recorded in the NSQIP Database from 2008–2012

Covariates	Change in operative time, minutes	*p-value*
Gender – Female	- 11.13	< 0.001
ASA Classification 1	- 23.96	0.03
ASA Classification 2	- 9.44	0.001
Race – Black or African American	10.79	0.02
Anesthesia – Regional	- 38.47	< 0.001
Anesthesia – Spinal	- 19.947	< 0.001
Previous percutaneous coronary intervention – Yes	- 10.093	0.03
Prior operation within 30 days – Yes	- 23.460	< 0.001
Current smoker within 1 year – Yes	- 9.958	0.01
Outpatient	- 40.224	< 0.001
Resident present	28.412	< 0.001

Abbreviation; ASA, American Society of Anesthesiologists.

associated with significantly shorter operation times. The use of spinal and regional anesthesia, rather than general anesthesia, was also associated with shorter operative times. Less expectedly, females, patients with a history of previous PCI, prior operation within 30 days, and smoking also experienced significantly shorter operative times.

Strengths and Limitations

The present study utilized the NSQIP database. This is a large database that allows access to a large, multicentered, multi-regional sample of revision THA procedures that specifically notate resident involvement. However, using this database comes with drawbacks. Extrapolating data from multiple

medical centers across the United States lends itself to a nonstandardized method of reporting data. There is no marker quantifying the degree of resident involvement or case complexity. The data was collected by a trained surgical reviewer. Neither the relative involvement of the resident or of the attending surgeon in the surgical steps was quantified in the data records. It is not possible to isolate the involvement of orthopedic residents, while controlling for other resident involvement in patient care. The database only collects outcomes within 30 days of surgery, so other long-term outcomes are not recorded. Additionally, a power analysis was not completed to ensure adequate sample size.

Despite these limitations, this is the largest study that evaluates the impact of resident involvement on acute postoperative complications for revision THA. A total of 1,743 revision THAs were evaluated, with 949 of those involving resident physicians. In the future, additional large, multicentered, prospective studies about resident involvement could support the results of the present study.

Conclusions

Overall, the present study showed that resident involvement in revision THA did not significantly impact outcomes including morbidity, mortality, and complication rates. Resident participation is associated with significantly increased operative time, but this did not translate into an increase in infection rate. Based upon these results, residents should continue to be involved in the surgical management of revision THA patients.

Ethical Approval

IRB approval was not necessary given that these data were obtained from a de-identified national database.

ACS NSQIP Disclaimer

The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or for the conclusions derived by the authors.

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Conflict of Interests

The authors have no conflict of interests to declare.

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