

Clinical Study

Impact of resident involvement on cervical and lumbar spine surgery outcomes

Kim Phan, BHSc^a, Philippe Phan, MD, PhD, FRCS(C)^a,
Alexandra Stratton, MD, MSc, FRCS(C)^a, Stephen Kingwell, MD, FRCS(C)^a,
Mohamad Hoda, PhD^a, Eugene Wai, MD, MSc, FRCS(C)^{a,b,*}

^a Division of Orthopaedic Surgery, Department of Surgery, University of Ottawa, The Ottawa Hospital, Ottawa, Ontario, Canada

^b Clinical Epidemiology Program, Ottawa Hospital Research Institute, Ottawa, Ontario, Canada

Received 21 February 2019; revised 11 July 2019; accepted 12 July 2019

Abstract

BACKGROUND CONTEXT: Resident involvement in the operating room is a vital component of their medical education. Conflicting and limited research exists regarding the effects of surgical participation on spine surgery patient outcomes.

PURPOSE: To determine the effect of resident involvement on surgery duration, length of hospital stay and 30-day postoperative complication rates in common spinal surgery using the American College of Surgeons' National Surgical Quality Improvement Program (ACS-NSQIP) database.

STUDY DESIGN: Multicenter retrospective cohort study.

PATIENT SAMPLE: A total of 1,441 patients met the inclusion criteria: 1,142 patients had surgeries with an attending physician alone and 299 patients had surgeries with trainee involvement. All anterior cervical or posterior lumbar surgery patients were identified. Patients who had missing trainee involvement information, surgery for cancer, preoperative infection or dirty wound classification, spine fractures, traumatic spinal cord injury, intradural surgery, thoracic surgery, and emergency surgery were excluded.

OUTCOME MEASURES: The main outcomes of interest analyzed from the ACS-NSQIP database included surgical complications, medical complications, length of hospital stay, and surgery duration.

METHODS: Propensity score for risk of any complication was calculated to account for baseline characteristic differences between the attending alone and trainee present group. Multivariate logistic regression was used to investigate the impact of resident involvement on surgery duration, length of hospital stay, and 30-day postoperative complication rates.

RESULTS: After adjusting using the calculated propensity score, the multivariate analysis demonstrated that there was no significant difference in any complication rates between surgeries involving trainees compared to surgeries with attending surgeons alone. Surgery times were found to be significantly longer for surgeries involving trainees. To further explore this relationship, separate analyses were performed for tertiles of predicted surgery duration, cervical or lumbar surgery, fusion or nonfusion, and inpatient or outpatient surgery. The effect of trainee involvement on increasing surgery time remained significant for medium predicted surgery duration, longer predicted surgery duration, cervical surgery, lumbar surgery, fusion surgery, and inpatient surgery. There were no significant differences reported for any other factors.

CONCLUSIONS: After adjusting for confounding, we demonstrated in a national database that resident involvement in surgeries did not increase complication rates. We demonstrated that surgeries with more complex features may lead to an increase in operative time when trainees are

FDA device/drug status: Not applicable.

Author disclosures: **KP:** Nothing to disclose. **PP:** Grant: Stryker Industrial (E). **AS:** Nothing to disclose. **SK:** Nothing to disclose. **MH:** Nothing to disclose. **EW:** Nothing to disclose.

* Corresponding author. The Ottawa Hospital, Civic Campus, 1053 Carling Ave, Ottawa, Ontario, Canada, K1Y 4E9. Tel.: (613) 798-5555 ext. 19138; fax: (613) 761-4944.

E-mail address: ewai@toh.ca (E. Wai).

involved. Further study is required to determine how to efficiently integrate resident involvement in surgeries without affecting their medical education. © 2019 Elsevier Inc. All rights reserved.

Keywords: Anterior cervical; Length of hospital stay; Posterior lumbar; Postoperative complications; Resident involvement; Surgery duration; Surgery outcomes

Introduction

Experience in the operating room is a vital component of surgical resident medical education. In order for surgical resident teaching programs to be optimized while also promoting the highest level of patient care, it is crucial that physicians and health-care institutions accurately understand the impact of resident involvement in surgeries on patient outcomes.

Although a number of prior studies have assessed the effect of trainee involvement on surgery outcomes, only a few have investigated the effect of trainee involvement on spine surgery specifically. These studies are limited in design or scope and present conflicting results [1–12]. Several studies have demonstrated that resident participation did not increase complications in plastic surgery, orthopedic surgery, urology, neurosurgery, and general surgery [1–6]. However, there have been other studies that concluded resident involvement increased risk of postoperative complications, operation duration, and length of hospital stay [7–12].

Residents mainly participate in surgeries at academic institutions which generally have patients with more complex cases and greater disease burdens [3]. A major limitation of the current body of research regarding the effect of resident involvement on surgical outcomes is that limited studies accounted for the complexity of the case or surgical diagnosis in their analysis. Disregarding the importance of these two factors may result in inaccurate findings, especially when analyzing surgeries involving residents.

Additional research is required to understand the full effects of resident involvement on spine surgery patient outcomes. To further the knowledge in this area, we analyzed the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) to evaluate the impact of resident participation during anterior cervical or posterior lumbar fusion surgery on surgery duration, length of hospital stay, and 30-day postoperative complication rates.

Materials and methods

The ACS-NSQIP database provides risk adjusted data based on 30-day postoperative surgical outcomes for over 2.9 million patients. The database consists of more than 150 preoperative, intraoperative, and 30-day postoperative variables that are collected prospectively from medical records and operative reports by on-site clinical reviewers.

The ACS-NSQIP database from 2005 to 2012 was used in this study. Preexisting procedure codes (CPT) and concurrent procedure codes, NSQIP prospectively collected

variables, and International Classification of Disease, ninth revision (ICD-9) diagnosis codes from the surgical report were used in the analysis.

Cases were included if information on trainee involvement was available and if anterior cervical or posterior lumbar surgery was the principle CPT code procedure. Please see [Supplementary Appendix A](#) for a list of all CPT codes used in the study. These regions were chosen for analysis because they are the two most commonly operated regions of the spine [13]. These procedures were selected for analysis because they were the most common procedures with the most robust data in the ACS-NSQIP database. Cases were excluded if the patient had surgery for cancer treatment, preoperative infection or dirty wound classification, spine fractures, traumatic spinal cord injury, intradural surgery, thoracic surgery, or emergency surgery ([Figure](#)).

Thirty-day postoperative complications were classified according to two categories: surgical and medical complications. Surgical site infection and wound dehiscence were combined as Surgical Site Infection (SSI). Surgical complications were defined as SSI, peripheral nerve injury at time of operation, graft failure at time of operation, unplanned return to the operating room (OR) within 30 days and postoperative surgical diagnosis or readmission diagnosis (including dural tear, neurologic complication, complication related to the device or implant, and hemorrhage complicating the procedure). Medical complications were defined as medical conditions that developed from nonsurgical causes and included cardiovascular, pulmonary, coma, renal, thromboembolic, and sepsis. The main outcomes of interest in this study included surgical complications, medical complications, and length of total hospital stay.

Propensity scores and other covariates were categorized into tertiles to represent high-, medium-, and low-risk surgery as well as shortest, medium, and longest predicted surgery duration to allow for improved clinical understanding and to explore for possible interacting effects and nonlinear trends. As there is no generally accepted cutoff for high, medium, and low risk or for short, medium, and long surgery duration, tertiles were arbitrarily used to define cutoffs to categorize these respective variables [14].

Results

There were no statistically significant baseline characteristic differences between the two cohorts with the exception of deformity correction as demonstrated in [Table 1](#). It is suspected that this difference is secondary to literature demonstrating that the use of two attending surgeons during a

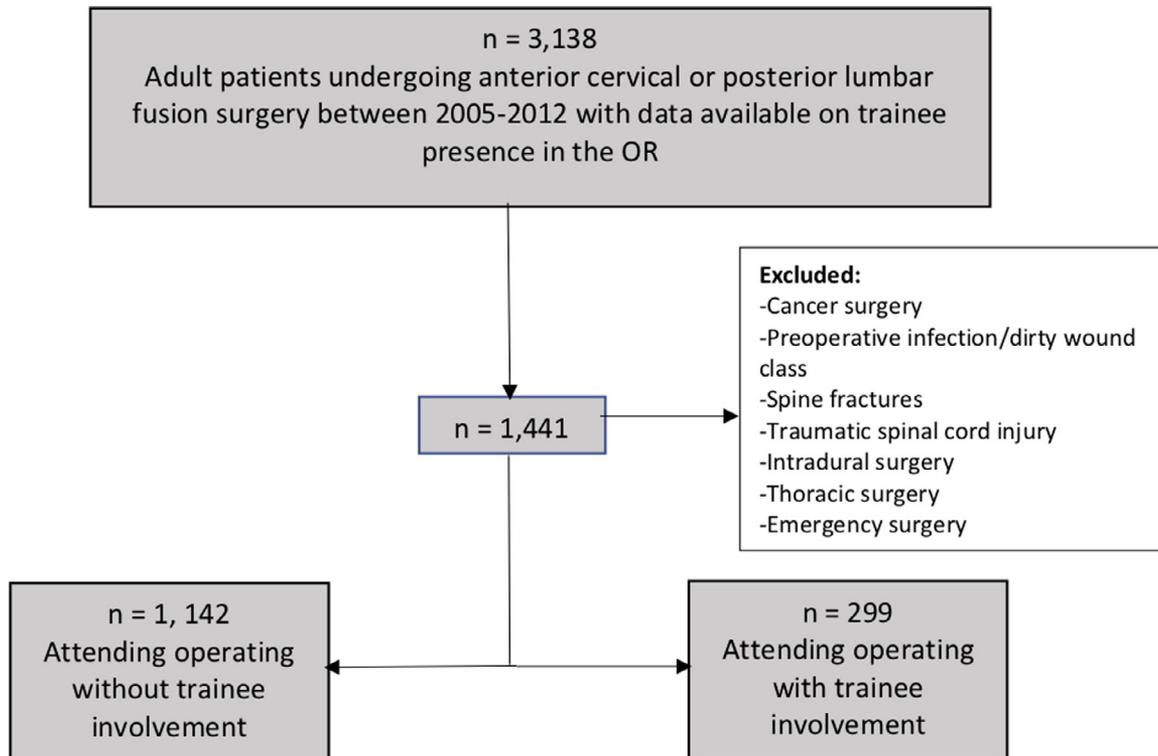


Figure. Patient selection criteria.

deformity correction leads to decreased complications, operative time, and predicted blood loss compared to the presence of one attending surgeon performing the surgery with trainees [15].

Propensity scores for risk of any complication were calculated in a multivariate logistic regression model, using the baseline patient characteristics. The propensity risk was then divided into tertiles to determine if there was any significant under-representation of a risk category between the groups. The largest discrepancy in distribution of risk tertile occurred in the lowest risk tertile with 30.5% in the trainee group and 34.1% in the no trainee group. In the multivariate model, female patients ($p=.0141$) inpatient surgeries ($p=.0172$) remained significantly associated with any complication. American Society of Anesthesiologists (ASA) grade trended toward a significant relationship with any complication (odds ratio=1.422 for each increase in ASA, 95% CI=0.943–2.146, $p=.0923$).

Adjusted analysis, using the calculated propensity score, demonstrated no significant difference in any complication between trainees or no trainees (adjusted odds ratio=0.944, 95% CI=0.559–1.591, $p=.8276$). To assess for interactions, separate adjusted analyses were performed for each tertile of risk, cervical or lumbar surgery, inpatient or outpatient surgery, and fusion or nonfusion lumbar surgery. None of these subgroup analyses demonstrated a significant effect for trainee involvement.

The impact of trainee training level on the outcome measures was assessed. Trainees in postgraduate year 1 to 3,

4 to 5, >5 were classified as junior, senior, or fellow, respectively. There was not a significant difference in total complication rates between junior, senior, or fellow training level (7.4%, 3.0%, and 6.7%, respectively, $p=.4655$) or in operating time (70.0 ± 30.6 , 68.9 ± 26.9 , 72.6 ± 38.8 minutes, respectively, $p=.7393$).

Predicted time of surgery was calculated in a multivariate regression model, using the patient baseline characteristics in Table 1. The predicted times were then divided into tertiles to determine if there was any significant under-representation of a predicted surgery duration between the groups. The largest discrepancy in distribution of predicted time of surgery tertile occurred in the shortest predicted surgery duration tertile with 25.2% in the trainee group and 35.4% in the no trainee group. In the multivariate model, higher age ($p=.0054$), higher ASA ($p<.0001$), neurosurgery ($p<.0144$), lumbar surgery ($p<.0001$), inpatient surgery ($p<.0001$), and deformity surgery ($p<.0001$) remained significantly associated with operative time. Using the predicted surgery times to adjust for all other variables, a multivariate regression model determined that surgery times were still significantly longer for trainee involvement (180.8 minutes ± 5.2 vs 158.5 ± 2.6 , 22.3 minutes longer for trainees, $p<.0001$) (Table 2).

To assess for interactions, separate analyses were performed for tertiles of predicted surgery duration, cervical or lumbar surgery, fusion or nonfusion, and inpatient or outpatient surgery. The effect of trainee involvement remained significant for medium predicted duration of surgery (25.8 minutes longer, $p<.0028$), longer predicted duration of

Table 1
Baseline characteristics of attending alone and trainee present cohorts

	Attending alone	Trainee present	p Value
Number of cases	1,142	299	N/A
Mean age	57.8±14.1	58.4±13.8	.4894
Gender = Male	565 (49.2%)	148 (48.7%)	.8795
Mean BMI	30.9±6.5	30.0±6.0	.0488
Modified Charlson Comorbidity Index			.9825
0	861 (74.9%)	229 (75.1%)	
1	227 (19.7%)	59 (19.3%)	
2	62 (5.39%)	17 (5.6%)	
American Society of Anesthesiologists (ASA) class			.5726
1	46 (4.0%)	17 (5.6%)	
2	640 (55.7%)	165 (54.1%)	
3	441 (38.4%)	119 (39.0%)	
4	22 (1.9%)	4 (1.3%)	
Current smoker	307 (26.7%)	65 (21.3%)	.0553
Surgical specialty			.0004
General surgery	3 (0.3%)	1 (0.33%)	
Neurosurgery	759 (66.0%)	237 (77.7%)	
Orthopedic	388 (33.7%)	67 (22.0%)	
Type of surgery			
Anterior cervical	374 (32.6%)	73 (23.9%)	
Posterior lumbar	775 (67.4%)	232 (76.%)	.0035
Outpatient	167 (14.5%)	27 (8.9%)	
Inpatient	983 (85.5%)	278 (92.2%)	.0098
Preop myelopathy (% of Cervical)	107 (28.5%)	29 (39.7%)	.0571
Adjunct surgery			
Deformity correction	25 (2.2%)	20 (6.7%)	<.0001
Revision	89 (7.7%)	25 (8.2%)	.7915
Lumbar fusion or instrumentation (% of lumbar)	114 (49.1%)	331 (42.7%)	.0837

± standard deviation (percentage).

surgery (29.8 minutes longer, $p < .0187$), cervical surgery (22.7 minutes longer, $p < .0001$), lumbar surgery (23.2 minutes longer, $p < .0001$), fusion surgery (35.7 minutes longer, $p = .0032$), and inpatient surgery (23.2 minutes longer, $p < .0001$). In contrast, shortest predicted duration of surgery tertile, outpatient surgery, and nonfusion surgery did not demonstrate a significant difference in surgery times between trainees and nontrainees.

Discussion

We demonstrated in a multicenter national database that resident involvement in surgeries did not increase complication rates. However, surgery duration was found to be significantly longer for surgeries involving trainees. It can be hypothesized that the differences in surgery duration between the two groups could be in part attributed to the fact that most trainees assist in academic hospitals where patients generally have more complex cases and greater disease burdens. To further explore this relationship, we performed separate analyses for tertiles of predicted surgery

Table 2
Unadjusted outcomes for attending alone and trainee present cohort

	Attending alone	Trainee present	p Value
Surgery time	155.2±92.7	191.2±114.6	<.0001*
Anesthesia time	66.5±33.0	66.8±32.5	.0605
Hospital length of stay (d)	3.0±3.2	3.5±4.0	.0492
Surgical site infection	18 (1.6%)	2 (0.66%)	.2809
Superficial			
Surgical complications	36 (3.1%)	8 (2.6%)	.6454
Medical complications	44 (3.8%)	11 (3.6%)	.8582
Any complication	75 (6.5%)	19 (6.2%)	.8536

* Denotes significant value, $p < .05$. ± denotes standard deviation (percentage).

duration, cervical or lumbar surgery, fusion or nonfusion, inpatient or outpatient surgery. The effect of trainee involvement on increased surgery time remained significant for medium predicted surgery duration, longer predicted surgery duration, cervical surgery, lumbar surgery, fusion surgery, and inpatient surgery. There were no significant differences reported for any other factors. We found that cases with the following features had a significant increase in surgical time when residents were involved compared to when the attending surgeon operated alone: longest and medium tertiles of predicted surgery duration, inpatient surgery, and fusion surgery. These features are representative of more complex surgeries as opposed to their counterpart features: shortest tertile of predicted surgery duration, outpatient surgery, and nonfusion surgery. These counterpart features were indicative of the cases that did not have a significant difference in surgical duration with the involvement of a resident. The results suggest that we were unable to properly account for features of surgical complexity in our analysis because there were still differences in surgical duration with trainee involvement after adjustment.

There are several studies assessing the effect of orthopedic surgery residents on outcomes which include spine surgery procedures [16–18]. Three of these studies use data from the ACS-NSQIP database and are organized in mixed groups of orthopedic surgery patients but have inconsistent conclusions. Edelstein et al. [16] concluded that resident participation in surgeries is associated with lower risk of perioperative complications and mortality. Pugely et al. [17] found that resident involvement is associated with higher postoperative complications in spine surgery patients but no significant increase in mortality. We hypothesize that the higher complication rate may be due to the fact that this study was unable to properly account for disease severity and case complexity. The third study conducted by Schoenfeld et al. [18] showed moderate risk of complications in joint arthroplasty cases but no significant risk for spine surgery cases when residents were involved. However, the spine surgery subsample in this study had a low prevalence of complications which resulted in inadequate power.

There are few studies published that are limited to spine surgery patients. A single-institution study of 303

consecutive scoliosis surgery cases concluded that resident participation resulted in longer operative time and was not associated with morbidity or mortality [19]. It is important to note that this association may have been caused by a type II error as the study had a low prevalence of complications and an underpowered sample size. Three spinal fusion studies using ACS-NSQIP data [20–22] found that there was a significant association between resident involvement and increased length of surgical time. They also concluded that resident involvement lead to a higher risk of wound complication, blood transfusion, and deep vein thrombosis, complications that have been previously associated with longer operative duration [23–25]. Interestingly, the study by Kim et al. [23] found that resident involvement was no longer significantly associated with increased risk for deep vein thrombosis once operative duration was accounted for in the analysis. However, the other studies did not conduct statistical analysis to determine if the increased surgery times resulted in higher risk of wound complications and transfusion and that the complications were not directly caused by the participation of residents in the surgery.

Existing literature is supported by our analysis as we found there to be significantly longer surgery duration when residents were involved. Our study's analysis adds to current literature by highlighting that surgeries with more complex features may lead to an increase in operative time when trainees are involved.

Although the study controlled for baseline variability in comorbidities between the two cohorts such as CCI, BMI, ASA class, preoperative myelopathy, and smoking history, a limitation of the study we recognize was the inadequate data on the mental health of the included patients that prevented us from controlling for anxiety and depression between the cohorts.

There were also several limitations to this study that are inherent to the ACS-NSQIP database. The observation period for this study is limited to 30 days' postoperation based on the data available from the ACS-NSQIP database. This short follow-up period means that long-term complications are not accounted for, potentially resulting in the under-reporting of postsurgery complications. Additionally, data from the ACS-NSQIP database are anonymized with respects to which institution it comes from as well as which surgeons are involved in the procedure. This presents a potential confounding factor as the study could not control for variability in the surgical technique involved. Moreover, CPT codes that are used to classify the surgical procedure performed on a patient do not perfectly describe what occurs in the operating room.

Furthermore, the ACS-NSQIP database does not provide information regarding the degree of resident participation in surgeries or the training experiences of other health-care providers also involved in the surgery. Residents mainly assist in surgeries conducted at academic hospitals which are also where other health-care trainees like nurses in training and anesthesiology residents learn. Since the level of

training of other health-care providers cannot be determined or controlled for, this may be a confounder that contributes to the longer surgery duration that is seen in surgical cases involving orthopedic residents.

Further study is required to determine how to efficiently integrate resident involvement in orthopedic surgeries without affecting their medical education. Doing so may enhance quality of care and patient safety.

Conclusions

We compared 30-day perioperative outcomes of anterior cervical or posterior lumbar fusion surgeries that were conducted by attending surgeon alone or with the assistance of residents.

Using a large, multi-institutional sample of prospectively collected data, we demonstrated that surgeries with more complex features may lead to an increase in operative time when trainees are involved. Our analysis suggests that the current practice of resident involvement in spine surgery is safe as our study showed that it had no effect on any complications.

Supplementary materials

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.spinee.2019.07.006>.

References

- [1] Saliba AN, Taher AT, Tamim H, Harb AR, Mailhac A, Radwan A, et al. Impact of resident involvement in surgery (IRIS-NSQIP): looking at the bigger picture based on the American College of Surgeons-NSQIP database. *J Am Coll Surg* 2016;222:30–40.
- [2] Tseng WH, Jin L, Canter RJ, Martinez SR, Khatri VP, Gauvin J, et al. Surgical resident involvement is safe for common elective general surgery procedures. *J Am Coll Surg* 2011;213:19–26.
- [3] Seicean A, Kumar P, Seicean S, Neuhauser D, Selman WR, Bambakidis NC. Impact of resident involvement in neurosurgery: an American College of Surgeons' National Surgical Quality Improvement Program database analysis of 33,977 patients. *Neurospine* 2018;15:54–65.
- [4] Jordan SW, Mioton LM, Smetona J, Aggarwal A, Wang E, Dumanian GA, et al. Resident involvement and plastic surgery outcomes: an analysis of 10,356 patients from the American College of Surgeons National Surgical Quality Improvement Program database. *Plast Reconstr Surg* 2013;131:763–73.
- [5] Matulewicz RS, Pilecki M, Rambachan A, Kim JYS, Kundu SD. Impact of resident involvement on urological surgery outcomes: an analysis of 40,000 patients from the ACS NSQIP database. *J Urol* 2014;192:885–90.
- [6] Cvetanovich GL, Schairer WW, Haughom BD, Nicholson GP, Romeo AA. Does resident involvement have an impact on postoperative complications after total shoulder arthroplasty? An analysis of 1382 cases. *J Shoulder Elbow Surg* 2015;24:1567–73.
- [7] Igwe E, Hernandez E, Rose S, Uppal S. Resident participation in laparoscopic hysterectomy: impact of trainee involvement on operative times and surgical outcomes. *Am J Obstet Gynecol* 2014;211:484.e1–7.
- [8] Iannuzzi JC, Rickles AS, Deeb A-P, Sharma A, Fleming FJ, Monson JRT. Outcomes associated with resident involvement in partial colectomy. *Dis Colon Rectum* 2013;56:212–8.

- [9] Whealon MD, Young MT, Phelan MJ, Nguyen NT. Effect of resident involvement on patient outcomes in complex laparoscopic gastrointestinal operations. *J Am Coll Surg* 2016;223:186–92.
- [10] Gorgun E, Benlice C, Corrao E, Hammel J, Isik O, Hull T, et al. Outcomes associated with resident involvement in laparoscopic colorectal surgery suggest a need for earlier and more intensive resident training. *Surgery* 2014;156:825–33.
- [11] Glance LG, Mukamel DB, Blumberg N, Fleming FJ, Hohmann SF, Dick AW. Association between surgical resident involvement and blood use in noncardiac surgery. *Transfusion* 2014;54:691–700.
- [12] Iannuzzi JC, Chandra A, Rickles AS, Kumar NG, Kelly KN, Gillespie DL, et al. Resident involvement is associated with worse outcomes after major lower extremity amputation. *J Vasc Surg* 2013;58:827–831.e1.
- [13] Sekhon LHS, Fehlings MG. Epidemiology, demographics, and pathophysiology of acute spinal cord injury. *Spine* 2001;26:S2–S12.
- [14] Altman DG. Categorising continuous variables. *Br J Cancer* 1991;64:975. Nature Publishing Group.
- [15] Ames CP, Barry JJ, Keshavarzi S, Dede O, Weber MH, Deviren V. Perioperative outcomes and complications of pedicle subtraction osteotomy in cases with single versus two attending surgeons. *Spine Deform* 2013;1:51–8.
- [16] Edelstein AI, Lovecchio FC, Saha S, Hsu WK, Kim JYS. Impact of resident involvement on orthopaedic surgery outcomes: an analysis of 30,628 patients from the American College of Surgeons National Surgical Quality Improvement Program database. *J Bone Joint Surg Am* 2014;96:e131.
- [17] Pugely AJ, Gao Y, Martin CT, Callagh JJ, Weinstein SL, Marsh JL. The effect of resident participation on short-term outcomes after orthopaedic surgery. *Clin Orthop Relat Res* 2014;472:2290–300.
- [18] Schoenfeld AJ, Serrano JA, Waterman BR, Bader JO, Belmont PJ. The impact of resident involvement on post-operative morbidity and mortality following orthopaedic procedures: a study of 43,343 cases. *Arch Orthop Trauma Surg* 2013;133:1483–91.
- [19] Auerbach JD, Lonner BS, Antonacci MD, Kean KE. Perioperative outcomes and complications related to teaching residents and fellows in scoliosis surgery. *Spine (Phila Pa 1976)* 2008;33:1113–8.
- [20] Kim RB, Garcia RM, Smith ZA, Dahdaleh NS. Impact of resident participation on outcomes after single-level anterior cervical discectomy and fusion. *Spine (Phila Pa 1976)* 2016;41:E289–96.
- [21] Kothari P, Lee NJ, Lakomkin N, Leven DM, Shin JI, Guzman JZ, et al. Impact of resident involvement on morbidity in adult patients undergoing fusion for spinal deformity. *Spine (Phila Pa 1976)* 2016;41:1296–302.
- [22] Lee NJ, Kothari P, Kim C, Leven DM, Skovrlj B, Guzman JZ, et al. The impact of resident involvement in elective posterior cervical fusion. *Spine (Phila Pa 1976)* 2018;43:316–23.
- [23] Kim JYS, Khavanin N, Rambachan A, McCarthy RJ, Mlodinow AS, De Oliveria GS, et al. Surgical duration and risk of venous thromboembolism. *JAMA Surg* 2015;150:110.
- [24] Procter LD, Davenport DL, Bernard AC, Zwischenberger JB. General surgical operative duration is associated with increased risk-adjusted infectious complication rates and length of hospital stay. *J Am Coll Surg* 2010;210:60–65.e2.
- [25] Ialenti MN, Lonner BS, Verma K, Dean L, Valdevit A, Errico T. Predicting operative blood loss during spinal fusion for adolescent idiopathic scoliosis. *J Pediatr Orthop* 2013;33:372–6.