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Int J Spine Surg 2021, 15 (3) 471-477
doi: https://doi.org/10.14444/8033
http://ijssurgery.com/content/15/3/471

Errata An erratum has been published regarding this article. Please see next page or: /content/17/5/751.full.pdf

The International Journal of Spine Surgery
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International Journal of Spine Surgery, Vol. 15, No. 3, 2021, pp. 471–477
https://doi.org/10.14444/8033

How Does the Presence of a Surgical Trainee Impact Patient Outcomes in Lumbar Fusion Surgery?

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ABSTRACT

Background: While the impact of trainee involvement in other surgical fields is well established, there is a paucity of literature assessing this relationship in orthopaedic spine surgery. The goal of this study was to further elucidate this relationship.

Methods: A retrospective cohort study was initiated on patients undergoing 1–3 level lumbar spine fusion at a single academic center. Operative reports from cases were examined, and patients were divided into 2 groups depending on whether a fellow or resident (F/R) or a physician's assistant (PA) was used as the primary assist. Patients with less than 1-year follow-up were excluded. Multiple linear regression was used to assess change in each patient-reported outcome, and multiple binary logistic regression was used to determine significant predictors of revision, infection, and 30- or 90-day readmission.

Results: One hundred and seventy-two patients were included in the F/R group compared with 178 patients in the PA group. No differences existed between groups for total surgery time, length of stay, 30- or 90-day readmissions, infection, or revision rates. No differences existed between groups in terms of patient-reported outcomes preoperatively or postoperatively. In addition, presence of a surgical trainee was not a significant predictor of patient outcomes or rates of infection, overall revision, or 30- and 90-day readmission rates.

Conclusions: The results of this study indicate the presence of an orthopaedic spine F/R does not increase complication rates and does not affect short-term patient-reported outcomes in lumbar decompression and fusion surgery.

Level of Evidence: 3.

Lumbar Spine

Keywords: resident, fellow, physician's assistant, PA, arthrodesis, readmission, infection, revision, patient-reported outcome measurements, PROMs

INTRODUCTION

Orthopaedic surgery residency and spine fellowship training programs have traditionally occurred at academic medical centers, where surgical skills are taught using techniques of graduated responsibility and autonomy within the operating room. As a core requirement in their training, fellows and residents (F/R) assist the primary attending on single-level and multi-level lumbar fusion surgeries. In nonacademic orthopaedic settings, an experienced physician's assistant (PA) will serve as the first assistant to primary attendings. Use of PAs in orthopaedic practices is becoming more commonplace, as hospitals and health care organizations seek to decreases costs, increase efficiency, and improve patient care by increasing consistency. PAs have been found to have little to no negative impact on health care outcomes or cost.[1]

With increased interest in patient-reported outcomes measures (PROMs) after surgery and improved access to large national databases, greater attention has been paid to the effects of F/R participation on patient outcomes after lumbar fusion surgery.[2] Current literature investigating spine surgery outcomes has shown F/R assistance is associated with increased operative times, higher estimated blood loss, and higher 30-day complication rates.[3–8] However, it remains unclear if trainee involvement can be attributed to the aforementioned differences in outcomes, as well as other factors such as the tendency for complex surgical cases to be done at an academic tertiary care center. Furthermore, data on PROMs based on trainee assistance are scarce.

In a large academic orthopaedic surgery practice, there is significant involvement of both surgical trainees and PAs during spine surgeries. At this institution, PAs work consistently with the same attending and essentially function equivalent to a high-level resident. They are involved in exposure of the spine, instrumentation, as well as assisting in decompression in a role like that of a senior resident. Surgical trainees at this institution include both residents (postgraduate year [PGY] 5) as well as orthopaedic spine fellows. In the operating room, only senior F/Rs assist attendings independently at a similar level. Therefore, the objective of this study is to compare patient outcomes after fusion surgery when a PA or surgical trainee participates as the first assistant.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board at the Thomas Jefferson University Hospital. Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. After institutional review board approval, a retrospective chart review was performed at a single academic medical center. Those patients who underwent a 1–3-level lumbar fusion between 2014 and 2017 were included in the study. Patients with less than 1-year follow-up data were excluded. Patient charts were analyzed for all operative reports. The cohort was divided into 2 groups based on the first assistant. The trainee group (F/R) consisted of all patients who had an orthopaedic surgery resident (PGY-5) or an orthopaedic spine fellow (PGY-6) as the primary assistant. The PA group consisted of all patients that had a PA as the primary assistant.

Demographic data that were identified from the medical record included age, sex, body mass index (BMI), smoking status (never, former, current), age-adjusted Charlson Comorbidity Index (CCI), months followed up, as well as preoperative diagnosis. Surgical variables that were recorded included type of fusion (posterolateral fusion, transforaminal lumbar interbody fusion, anterior lumbar interbody fusion), total surgery time (from incision to closure), number of levels fused, and number of levels decompressed. The total length of hospital stay (days), 30- and 90-day readmission rates, presence of postoperative wound infection, and need for revision surgery at 1 year were also recorded. Finally, PROMs were recorded preoperatively and at final follow-up, including Short Form-12 Physical Component Score (SF-12 PCS), Short Form-12 Mental Component Score (SF-12 MCS), Oswestry Disability Index (ODI), and Visual Analogue Scale for back pain (VAS back) and leg pain (VAS leg).

Univariate analysis with a Student's *t* test was used to compare differences between continuous data in the 2 groups. Categorical data were compared using a χ^2 test. Preoperative, postoperative, and Δ (postoperative − preoperative score) outcome measures for each scale were compared between groups. In addition to Δ scores, improvement over time between groups was compared with 2 additional measures: recovery ratios (RRs) and the percentage of patients reaching the minimum clinically important difference (% MCID) by the 1-year postoperative mark. Recovery ratios were calculated as [Δ score/(optimal score − baseline score)], using the following set of "optimal" scores for each PROM: PCS-12 = 100 points; ODI/VAS back/VAS leg = 0 points.[9] The % MCID was calculated using the following validated threshold values: PCS-12 = 8.8 points, ODI = 6.8 points, VAS back = 2.1 points, and VAS leg = 2.4 points.[10,11] Multiple linear regression was used to determine if presence of a surgical trainee was a significant predictor of any PROM, adjusting for age, sex, BMI, CCI, preoperative diagnosis, months followed up, surgery type, number of levels fused, total surgery time, and length of stay. Finally, multiple binary logistic regression was used to determine significant predictors of need for revision, postoperative wound infection, and 30- and 90-day readmission while adjusting for the same demographic variables.

RESULTS

A total of 350 patients that underwent 1–3-level lumbar spinal fusion with 1–5 levels of decompression were included in the final analysis. The F/R group consisted of 172 patients (145 with fellow assistance, 27 with resident assistance) compared

Table 1. Baseline characteristics for fellow/resident (F/R) versus physician's assistant (PA) in lumbar fusion surgery.

	F/R, n = 172	PA, n = 178	*P* Value
Age, mean [95% CI], y	63.6 [62.0, 65.2]	62.0 [60.3, 63.7]	.142
Sex, n (%)			
Female	91 (52.9)	103 (57.9)	.351
Male	81 (47.1)	75 (42.1)	
BMI, mean [95% CI],	30.9 [30.0, 31.9]	30.5 [29.6, 31.4]	.487
Smoking status, n (%)			
Never	113 (65.7)	121 (68.0)	.863
Former	42 (24.4)	42 (23.6)	
Current	17 (9.9)	15 (8.4)	
Age-adjusted CCI, mean [95% CI]	3.40 [3.07, 3.74]	2.69 [2.39, 3.00]	.002[a]
Follow-up, mean [95% CI], mo	13.4 [12.7, 14.1]	13.4 [12.1, 14.7]	.535
Preoperative diagnosis, n (%)			
Spondylolisthesis	145 (84.3)	134 (75.3)	.535
Scoliosis	19 (11.0)	29 (16.3)	
Stenosis (wide decompression)	8 (4.7)	15 (8.4)	
Surgery type, n (%)			
PLF	100 (58.1)	96 (53.9)	.721
TLIF	59 (34.3)	68 (38.2)	
ALIF	13 (7.6)	14 (7.9)	
No. levels fused, n (%)			
1	122 (70.9)	118 (66.3)	.497
2	38 (22.1)	49 (27.5)	
3	12 (7.0)	11 (6.2)	
No. levels decompressed, n (%)			
1	73 (42.4)	77 (43.3)	.640
2	53 (30.8)	60 (33.7)	
3	36 (20.9)	27 (15.2)	
4	8 (4.7)	12 (6.7)	
5	2 (1.2)	2 (1.1)	
Surgery time, mean [95% CI], min	295.3 [277.9, 312.7]	293.9 [271.8. 315.9]	.835
Length of stay, mean [95% CI], d	4.5 [4.2, 4.8]	4.1 [3.9, 4.4]	.103
Readmissions, n (%)			
Within 30 d	5 (2.9)	1 (0.6)	.116
Within 90 d	9 (5.2)	2 (1.1)	.082
All-cause revision, n (%)			
No	165 (95.8)	172 (96.6)	.094
Yes	16 (9.7)	8 (4.7)	
Infection	5 (2.9)	1 (0.6)	.091
Mechanical	11 (6.4)	7 (3.9)	.297

Abbreviations: ALIF, anterior lumbar interbody fusion; BMI, body mass index; CCI, Charlson Comorbidity Index; CI, confidence interval; PLF, posterolateral fusion; TLIF, transforaminal lumbar interbody fusion.
[a]Value is statistically significance ($P < .05$).

with 178 patients in the PA group. Patient demographics and surgical variables for the F/R and PA groups are listed in Table 1. No significant difference existed between groups in terms of age ($P = .142$), sex ($P = .351$), BMI ($P = .487$), smoking status ($P = .863$), months followed up ($P = .535$), or preoperative diagnosis ($P = .535$). A significant baseline difference existed in CCI, with the F/R group having more comorbidities (3.40, 95% confidence interval (CI) [3.07, 3.74] versus 2.69 [2.39, 3.00], $P = .002$). Regarding surgical variables, no difference existed in surgery type ($P = .721$), number of levels fused ($P = .497$), and number of levels decompressed ($P = .640$). In addition, no significant difference existed in total surgery time between the F/R group (295.3 min [277.9, 312.7]) and the PA group (293 min [271.8, 315.9], $P = .835$). Length of stay was also comparable for the F/R and PA groups (4.5 versus 4.1 days, $P = .103$).

Rates of long-term complications between the 2 groups were found to be similar. Five readmissions occurred within 30 days for the F/R group compared with 1 readmission for the PA group ($P = .116$). Similarly, 9 readmissions occurred within 90 days for the F/R group and 2 readmissions for the PA group ($P = .082$). Overall revision rates at final follow-up were not significantly different between groups (9.7% versus 4.7% for the F/R and PA groups, respectively; $P = .094$). Further stratification for cause of revision also showed no differences between the F/R and PA groups: infection (2.9% versus 0.6%, $P = .091$) and mechanical (6.4% versus 3.9%, $P = .297$).

Table 2. Patient-reported outcome measurement comparisons between groups.

	Univariate Analysis			Multivariate Analysis	
	Fellow/Resident	Physician's Assistant	P^a	β Coefficient	P^b
PCS-12					
Pre, mean [95% CI]	30.7 [29.3, 32.1]	30.6 [29.3, 31.0]	.999	1.665 [−2.119, 5.449]	.386
Post, mean [95% CI]	38.8 [37.0, 40.7]	40.7 [39.0, 42.4]	.135		
Δ, , mean [95% CI]	8.2 [6.5, 9.9]	10.0 [8.3, 11.7]	.152		
RR, %	11.3	13.7	.160		
% MCID	46.4	52.9	.255		
P^c	<.001[d]	<.001[d]	NA		
MCS-12					
Pre, mean [95% CI]	49.0 [46.9, 51.1]	49.5 [47.7, 51.3]	.355	−1.542 [−5.140, 2.055]	.398
Post, mean [95% CI]	53.2 [51.4, 54.9]	53.1 [51.7, 54.9]	.307		
Δ, mean [95% CI]	4.0 [2.2, 5.7]	3.5 [1.8, 5.2]	.714		
RR, %	5.1	4.6	.838		
% MCID	27.7	27.2	.917		
P^c	<.001[d]	<.001[d]	NA		
ODI					
Pre, mean [95% CI]	41.4 [38.4, 44.5]	41.7 [39.2, 44.1]	.654	−3.592 [−11.231, 4.047]	.354
Post, mean [95% CI]	23.0 [19.9, 26.2]	20.6 [17.6, 23.7]	.201		
Δ, mean [95% CI]	−17.5 [−21.1, −13.9]	−22.4 [−25.7, −19.2]	.045[a]		
RR, %	33.9	44.3	.257		
% MCID	65.2	78.8	.010[a]		
P^c	<.001[d]	<.001[d]	NA		
VAS back					
Pre, mean [95% CI]	5.94 [5.40, 6.48]	5.94 [5.51, 6.37]	.775	−0.097 [−1.262, 1.067]	.869
Post, mean [95% CI]	2.90 [2.42, 3.38]	2.91 [2.47, 3.35]	.935		
Δ, mean [95% CI]	−3.0 [−3.5, −2.4]	−3.1 [−3.6, −2.6]	.841		
RR, %	35.6	44.5	.388		
% MCID	57.1	55.1	.715		
P^c	<.001[d]	<.001[d]	NA		
VAS leg					
Pre, mean [95% CI]	6.27 [5.70, 6.83]	5.93 [5.48, 6.39]	.310	−0.876 [−2.181, 0.428]	.186
Post, mean [95% CI]	2.75 [2.20, 3.39]	2.31 [1.86, 2.77]	.071		
Δ, mean [95% CI]	−3.5 [−4.1, −2.9]	−3.6 [−4.2, −3.0]	.755		
RR, %	53.8	58.1	.531		
% MCID	58.9	60.1	.828		
P^c	<.001[d]	<.001[d]	NA		

Abbreviations: CI, confidence interval; % MCID, minimum clinically important difference; MCS-12, Mental Component Score of SF-12; NA, not applicable; ODI, Oswestry Disability Index; PCS-12, Physical Component Score of SF-12; RR, recovery ratio; VAS, Visual Analog Scale.
[a]Independent *t* test or Mann-Whitney *U* test used to compare means.
[b]Multiple linear regression model used to compare magnitude of change in patient-reported outcome.
[c]Paired samples *t* test to compare within-groups changes over time.
[d]Value is statistically significance ($P < .05$).

When analyzing PROMs within groups, both groups improved significantly from preoperative to postoperative measurements for all outcome measures ($P < .001$). No significant differences existed between groups preoperatively or postoperatively for PCS-12, MCS-12, VAS back, and VAS leg scores. Patients in the PA group showed a significantly larger decrease in ODI than the F/R group (–22.4 [–25.7, –19.2] versus –17.5 [–21.1, –13.9], $P = .045$). Additionally, a higher proportion of patients in the PA group achieved MCID than the F/R group (78.8% versus 65.2%, $P = .010$). Results from the multiple linear regression analysis showed that the presence of a surgical trainee was not an independent predictor of any PROM. Similarly, on multiple logistic regression analysis, presence of a trainee was not an independent predictor of overall revision rates, infection rates, or 30- and 90-day readmission rates. PROMs comparisons can be located in Table 2.

DISCUSSION

In a high-volume surgical institution, having adequate intraoperative assistance from trainees and PAs is necessary in maintaining efficiency. Traditionally, academic centers have an important role in conducting surgical training for F/Rs. With increasing patient volume, a drive toward value-based care, and restrictions with resident duty hours, many hospital systems have begun to use PAs to fill gaps in patient care.[12,13] While authors have shown the safety and efficacy of incorporating PAs onto surgical services, no authors have directly compared the effect of using PAs or surgical trainees in spine surgery.[13] Therefore, the goal of this study was to evaluate outcome differences of lumbar fusion surgery based on whether the first assistant was a F/R compared with the surgeon's PA.

In the present study, both groups improved significantly from preoperatively to postoperatively for all patient outcome measures. Multivariate analysis showed that the presence of a surgical trainee was not an independent predictor of any PROM or any complication, even when adjusting for baseline differences. In addition, despite operating on patients with significantly more medical comorbidities, F/Rs had a similar total surgery time and lengths of stay compared with PAs as first assists. In addition, no differences existed in rates of postoperative complications, readmission rates at 30- and 90-day intervals, or revision rates. These results are comparable with those reported by Kim et al,[6] who found that resident participation increased operative duration but did not increase risk of any complications or length of stay in patients undergoing single-level anterior cervical discectomy and fusion (ACDF). Also using the National Surgical Quality Improvement Program (NSQIP) database, Edelstein et al[8] found that resident involvement in orthopaedic cases was even associated with decreased perioperative mortality and complications. In perhaps the only other study to also include surgical fellows, Auerbach et al[3] reported that when comparing the combination of F/Rs with junior or senior attendings as first assist in scoliosis surgery cases, increased operative time and blood loss occurred in the former group, but overall no differences in curve correction, length of stay, or early complication rates. The authors concluded that, without an increase in complications, training F/Rs in these cases were safe. Authors of all these studies suggest that surgical trainee involvement is not detrimental to overall outcomes and, in some cases, may actually be beneficial.

However, authors of other studies within spine surgery have reported opposite findings for the impact of resident involvement. Pugely et al[14] found that resident participation was associated with higher morbidity, operative time, length of stay, and 30-day reoperation rates for spine fusions. They found that level of resident training, however, did not affect surgical outcomes.[14] Similarly, Yamaguchi et al[5] found that resident involvement in lumbar fusion procedures was an independent predictor of increased hospital stay, total operative time, sepsis, development of deep venous thrombosis or pulmonary embolism, and superficial surgical site infections. Lee et al[7] studied the impact of resident involvement in elective posterior cervical fusion and found that resident participation was not associated with mortality but was a significant predictor of blood transfusions and length of stay >5 days. Studying the impact of resident involvement in patients undergoing spine deformity surgery, Kothari et al[4] found that resident participation was associated with a longer operative time and an independent predictor of overall morbidity, wound complication, transfusion rates, and length of stay >5 days. The authors of these studies imply that resident involvement may actually lengthen surgery and increase complications. However, since all these studies were performed using the NSQIP database, they represent subsets of the same overall cohort. In addition, the types of surgeries involved may be very heterogeneous and difficult to compare across studies. Lastly, this database only provides information regarding postoperative complications and does not include information about health care-related quality of life measures.

With the increased rise in use of PAs across all areas of medicine, a few authors have reported the effects of using PAs in a surgical practice. Althousen et al[15] found that indirect financial and patient care impact by PAs was overwhelmingly positive, as PAs helped to see trauma patients earlier, decrease emergency department wait times, and decrease the time from injury to surgery. In addition, PAs have been estimated to save orthopedic surgeons up to 204 hours a year by increasing operative efficiency.[16] Up to 87.6% of orthopedic practices use PAs in the operating room on a regular basis and, often times, as primary assistants.[17] Despite this, currently studies are lacking in which authors evaluate the effect of orthopedic PA assistance on the short- and long-term PROMs after lumbar fusion surgery. In the present study, patients in the PA group had a larger improvement with respect to ODI scores than the F/R group (–22.4 versus –17.5, $P = .045$). In addition, the PA group had a larger proportion of patients achieving MCID (78.8% versus 65.2%, $P = .010$). Patients in the PA group also had a lower CCI, which may reflect selection bias in these cases. However, even when adjusting for these baseline differences, presence of a PA was not an independent predictor of any PROM or complication on multivariate analysis, suggesting that further research with larger patient cohorts is needed.

Important limitations should be considered in the study. Only patients undergoing lumbar spine fusion for degenerative causes from 1 to 3 levels were included. These cases typically provide reliable outcomes and minimal variation with regard to complications. Intraoperative blood loss was not available for all cases and thus not included in the statistical analysis. This analysis was performed at a single institution and provides a limited perspective with regard to practice patterns, patient population, and surgical technique. In addition, all the previous NSQIP studies used propensity score matching from a much larger database to create equally matched groups. Despite the underlying difference in CCI between groups, propensity matching in this cohort would not have allowed a meaningful analysis between patients due to a smaller sample size available. In addition, the variability of training and interest in the F/R group between PGY-5 residents and spine fellows may be quite significant, which may have contributed to group heterogeneity. Similarly, all PAs may have different levels of comfort with surgical procedures; however, all the PAs in this study worked with their respective surgeon daily for at least 2 years. Despite these weaknesses, this study has several strengths, including that it is the first study, to our knowledge, on F/R and PA involvement that includes PROMs up to 1 year. In addition, compared with the NSQIP database, this single-institution database provides more accurate data with regard to patient medical history as well as patient follow-up with complication rates up to 1 year.

CONCLUSIONS

Patients in the PA group had larger improvements in ODI with a larger proportion achieving MCID than patients in the F/R group. However, the presence of a surgical trainee was not found to be an independent predictor of any PROM or complication up to the 1-year point. To our knowledge, this is the first study to compare patient outcomes between F/R involvement with PA involvement in lumbar fusion surgery. Further research with larger cohorts is needed to validate these findings.

REFERENCES

1. Halter M, Wheeler C, Pelone F, et al. Contribution of physician assistants/associates to secondary care: a systematic review. *BMJ Open*. 2018;8:e019573. doi:10.1136/bmjopen-2017-019573

2. Baumhauer JF, Bozic KJ. Value-based healthcare: patient-reported outcomes in clinical decision making. *Clin Orthop Relat Res*. 2016;474(6):1375–1378. doi:10.1007/s11999-016-4813-4

3. 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(10):1113–1118. doi:10.1097/BRS.0b013e31816f69cf

4. Kothari P, Lee NJ, Lakomkin N, et al. Impact of resident involvement on morbidity in adult patients undergoing fusion for spinal deformity. *Spine (Phila Pa 1976)*. 2016;41(16):1296–1302. doi:10.1097/BRS.0000000000001522

5. Yamaguchi JT, Garcia RM, Cloney MB, Dahdaleh NS. Impact of resident participation on outcomes following lumbar fusion: an analysis of 5655 patients from the ACS-NSQIP database. *J Clin Neurosci*. 2018;56:131–136. doi:10.1016/j.jocn.2018.06.030

6. Kim RB, Garcia RM, Smith ZA, Dahdaleh NS. Impact of resident participation on outcomes after single-level anterior cervical diskectomy and fusion. *Spine (Phila Pa 1976)*. 2016;41(5):E289–96. doi:10.1097/BRS.0000000000001230

7. Lee NJ, Kothari P, Kim C, et al. The impact of resident involvement in elective posterior cervical fusion. *Spine (Phila Pa 1976)*. 2018;43(5):316–323. doi:10.1097/BRS.0000000000001477

8. 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(15):e131. doi:10.2106/JBJS.M.00660

9. Radcliff K, Davis RJ, Hisey MS, et al. Long-term evaluation of cervical disc arthroplasty with the Mobi-C© cervical disc: a randomized, prospective, multicenter clinical trial with seven-year follow-up. *Int J Spine Surg*. 2017;11(4):31. doi:10.14444/4031

10. Parker SL, Adogwa O, Paul AR, et al. Utility of minimum clinically important difference in assessing pain, disability, and health state after transforaminal lumbar interbody fusion for degenerative lumbar spondylolisthesis. *J Neurosurg Spine*. 2011;14(5):598–604. doi:10.3171/2010.12.SPINE10472

11. Parker SL, Mendenhall SK, Shau D, et al. Determination of minimum clinically important difference in pain, disability, and quality of life after extension of fusion for adjacent-segment disease. *J Neurosurg Spine*. 2011;16(1):61–67. doi:10.3171/2011.8.spine1194

12. Reed DO, Hooker RS. PAs in orthopedics in the VHA's community-based outpatient clinics. *J Am Acad Physician Assist*. 2017;30(4):38–42. doi:10.1097/01.JAA.0000513352.60771.0a

13. Johal J, Dodd A. Physician extenders on surgical services: a systematic review. *Can J Surg*. 2017;60(3):172–178. doi:10.1503/cjs.001516

14. Pugely AJ, Gao Y, Martin CT, Callaghan JJ, Weinstein

SL, Marsh JL. The effect of resident participation on short-term outcomes after orthopaedic surgery. *Clin Orthop Relat Res*. 2014;472(7):2290–2300. doi:10.1007/s11999-014-3567-0

15. Althausen PL, Shannon S, Owens B, et al. Impact of hospital-employed physician assistants on a Level II community-based orthopaedic trauma system. *J Orthop Trauma*. 2013;27(4):e87–91. doi:10.1097/BOT.0b013e3182647f29

16. Bohm ER, Dunbar M, Pitman D, Rhule C, Araneta J. Experience with physician assistants in a Canadian arthroplasty program. *Can J Surg*. 2010;53(2):103–108.

17. Larson EH, Coerver DA, Wick KH, Ballweg RA. Physician assistants in orthopedic practice: a national study. *J Allied Health*. 2011;40(4):174–180.

Disclosures and COI: The authors, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article. There are no relevant disclosures.

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Published 1 June 2021

International Journal of Spine Surgery, Vol. 17, No. 5, 2023, pp. 751
https://doi.org/10.14444/8033cxx

Corrections

Divi SN, Goyal DKC, Hoffman E, et al. How does the presence of a surgical trainee impact patient outcomes in lumbar fusion surgery? *Int J Spine Surg*. 2021;15(3):471-477. https://doi.org/10.14444/8033

Two authors names were presented incorrectly in this article. DHruv K.C. Goyal should have appeared as Dhruv K.C. Goyal. Also, Matt Galtta should have appeared as Matthew S. Galetta. (doi:10.14444/8033cxx)