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Longitudinal Assessment of Modern Spine Surgery Training

10-Year Follow-up of a Nationwide Survey of Residency and Spine Fellowship Program Directors

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Background: Spine surgeons complete training through residency in orthopaedic surgery (ORTH) or neurosurgery (NSGY). A survey was conducted in 2013 to evaluate spine surgery training. Over the past decade, advances in surgical techniques and the changing dynamics in fellowship training may have affected training and program director (PD) perceptions may have shifted.

Methods: This study is a cross-sectional survey distributed to all PDs of ORTH and NSGY residencies and spine fellowships in the United States. Participants were queried regarding characteristics of their program, ideal characteristics of residency training, and opinions regarding the current training environment. χ^2 tests were used to compare answers over the years.

Results: In total, 241 PDs completed the survey. From 2013 to 2023, NSGY increased the proportion of residents with >300 spine cases (86%-100%) while ORTH remained with >90% of residents with < 225 cases ($p < 0.05$). A greater number of NSGY PDs encouraged spine fellowship even for community spine surgery practice (0% in 2013 vs. 14% in 2023, $p < 0.05$), which continued to be significantly different from ORTH PDs (~88% agreed, $p > 0.05$). 100% of NSGY PDs remained confident in their residents performing spine surgery, whereas ORTH confidence significantly decreased from 43% in 2013 to 25% in 2023 ($p < 0.05$). For spinal deformity, orthopaedic PDs (92%), NSGY PDs (96%), and fellowship directors (95%), all agreed that a spine fellowship should be pursued ($p = 0.99$). In both 2013 and 2023, approximately 44% were satisfied with the spine training model in the United States. In 2013, 24% of all PDs believed we should have a dedicated spine residency, which increased to 39% in 2023 (fellowship: 57%, ORTH: 38%, NSGY: 21%) ($p < 0.05$).

continued

This study does not involve human or animal participants and did not require IRB approval.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (<http://links.lww.com/JBJSOA/A538>).

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Conclusion: Spine surgery training continues to evolve, yet ORTH and neurological surgery training remains significantly different in case volumes and educational strengths. In both 2013 and 2023, less than 50% of PDs were satisfied with the current spine surgery training model, and a growing minority believe that spine surgery should have its own residency training pathway.

Level of Evidence: IV.

Introduction

Spine surgeons are currently trained through a residency in orthopaedic surgery (ORTH) or neurological surgery, followed by an optional spine fellowship¹. Training in the diagnosis and management of adult and pediatric spinal disorders is required by the Accreditation Council for Graduate Medical Education (ACGME), regardless of which residency pathway trainees choose². Although there are published guidelines for spine surgical training, regardless of route of residency, the distinct training models provide variable exposure for case volume, length of training, and spinal pathology encountered^{3,5}.

Currently, nearly all orthopaedic trainees undergo a spine surgery fellowship before independently performing spine surgery. However, with a higher volume of cases and greater emphasis on spinal pathology in neurological surgical residency, neurosurgical trainees often perform spine surgery without further training. Thus, the individual objectives of residency training may differ; orthopaedic residency teaches residents the substratum of spine surgery as a foundation for further fellowship while neurological surgery residency attempts to provide residents with the skill set required to practice independent spine surgery⁶.

With different training routes that provide a distinct emphasis, controversy exists in the optimal process to train spine surgeons⁵. In 2013, a survey study was conducted to evaluate the state of spine training in the United States, which won the John H. Moe Award at the Scoliosis Research Society Annual Meeting⁶, in which orthopaedic and neurological surgery residency and spine fellowship program directors (PDs) were queried for their opinions on the current state and their ideal vision of spine surgery training. This study revealed significant differences between orthopaedic surgery and neurological surgery in the exposure to spine surgery case volumes and opinions regarding the necessity of a further spine surgery fellowship.

In the 2013 survey, over 80% of PDs believed that both orthopaedic and neurological surgery trainees should complete a fellowship if they wish to pursue spinal deformity surgery⁶. Furthermore, nearly all PDs believed that ORTH residents should complete a spine fellowship if they wish to practice community spine surgery. In addition, the study revealed a growing dissatisfaction with the current spine training model with only 29% of spine fellowship directors stating that they were satisfied.

With advances in surgical techniques, changing landscapes in spine surgery training, evolving medicolegal concerns, and the growth of fellowship opportunities, it is unknown how the perception of spine training among PDs has shifted since the initial survey performed in 2013. The aim of this study was to investigate

the current perception of the state of spine training in the United States and evaluate the change in residency and fellowship directors' responses over the past decade.

Methods

Study Setting

The researchers obtained institutional review board exemption before completing this investigation. An anonymous 24-question online survey was distributed to PDs of ACGME-accredited ORTH and neurological surgery residency programs using Google Forms (<https://www.google.com/forms/about>). Residency PDs were identified using the Fellowship and Residency Electronic Interactive Database Access System database from the American Medical Association. A similar 40-question survey was distributed to spine surgery fellowship PDs (orthopaedic and neurosurgical spine fellowships) in the United States. Fellowship PDs were identified using the North American Spine Society and the American Association of Neurological Surgeons directories.

In total, the survey was forwarded to 466 PDs (residency programs, N = 322; spine fellowship, N = 144). A reminder email was delivered 2 weeks after survey distribution. Results were reported and analyzed for the total number of individuals who answered each question.

Statistical Analysis

Statistical analysis was performed using SPSS 27 (IBM). The χ^2 test of association was used to compare the responses of orthopaedic residency, neurosurgical residency, and spine fellowship PDs for each question independently. χ^2 tests of association were also used to compare the results of the 2013 study with the 2023 study.

Results

A total of 94 PDs completed the 2023 survey. This included 52 residency PDs (N = 24 orthopaedic surgery, N = 28 neurosurgery [NSGY]) and 42 fellowship PDs (N = 22 orthopaedic surgery, N = 20 NSGY). A true response rate could not be calculated because it is uncertain how many PDs received the email and viewed the survey; however, the completion rate for those initiating the survey was 100%.

Residency Program and Spine Fellowship Program Director Responses

Orthopaedic residency PDs stated that 15% of their residents choose spine as a specialty, compared with 44% of the neurosurgical residents ($p < 0.001$). 50.00% of orthopaedic residency PDs stated that their residents will perform 76 to 150

TABLE I Residency Program Director Response Data			
	Orthopaedic Surgery (N = 24)	Neurosurgery (N = 28)	p
How many trainees does your program accept per year (mean)?	4.75	1.89	
Approximately what percentage of your residents choose spine as a specialty (mean)?	15%	44%	<0.001
How many months do your residents spend on a dedicated spine surgery service during residency?			
0-1	4.17%	39.29%	
2-4	58.33%	7.14%	
5-6	29.17%	10.71%	
7-8	8.33%	3.57%	
9-10	0.00%	0.00%	
11-12	0.00%	0.00%	
>12	0.00%	39.29%	<0.001
How many total months <i>should</i> residents spend during residency on a dedicated spine surgery service?			
0-1	4.17%	14.29%	
2-4	54.17%	0.00%	
5-6	33.33%	28.57%	
7-8	8.33%	3.57%	
9-10	0.00%	0.00%	
11-12	0.00%	10.71%	
>12	0.00%	42.86%	<0.001
How many months do your residents spend on a service which performs some spine surgery along with other types of surgery (not a dedicated spine service)?			
0-1	16.67%	0.00%	
2-4	25.00%	3.57%	
5-6	41.67%	0.00%	
7-8	0.00%	0.00%	
9-10	8.33%	3.57%	
11-12	0.00%	3.57%	
>12	8.33%	89.29%	<0.001
Approximately how many TOTAL spine surgery procedures do your residents log at the completion of residency training?			
0-75	20.83%	0.00%	
76-150	50.00%	0.00%	
151-225	20.83%	0.00%	
226-300	0.00%	0.00%	
301-375	8.33%	10.71%	
376-450	0.00%	14.29%	
>450	0.00%	75.00%	<0.001
At the conclusion of your training program, how do you rank your residents' confidence in diagnosis and investigation of spinal pathology?			
Very confident/confident	58.33%	100.00%	
Average confidence	41.67%	0.00%	
A little confident/not at all confident	0.00%	0.00%	<0.001
At the conclusion of your training program, how do you rank your residents' confidence in management of spinal pathologies, including performing spine surgery?			
Very confident/confident	25.00%	100.00%	
Average confidence	37.50%	0.00%	
A little confident/not at all confident	37.50%	0.00%	<0.001

Bold indicates p < 0.05.

TABLE II Fellowship Program Director Response Data*			
	Orthopaedic Surgery (N = 22)	Neurosurgery (N = 20)	p
How many trainees does your program accept per year (mean)?	1.82	1.71	
Is your fellowship ACGME-approved?			
Yes	22.73%	40.00%	
No	77.27%	60.00%	0.23
For fellowship: does your program accept			
Ortho only	27.27%	0.00%	
Neuro only	0.00%	50.00%	
Both	72.73%	50.00%	<0.001
If both and 2 applicants were similar on paper, would you favor			
Orthopaedic	31.82%	0.00%	
Neurosurgery	0.00%	25.00%	
Comparable	40.91%	25.00%	0.002
If both, has there been a trend toward higher number of neurosurgery applicants to orthopaedic spine fellowships?			
Yes	40.91%	25.00%	
No	31.82%	25.00%	0.76
Do you think spine fellowship training should be collaborative between neurosurgery and orthopaedic surgery departments?			
Yes	81.82%	70.00%	
Maybe	18.18%	25.00%	
No	0.00%	5.00%	0.53
Do you recommend a second fellowship to your fellows if they wish to perform complex spine surgery?			
Yes	4.55%	25.00%	
Maybe	36.36%	10.00%	
No	59.09%	65.00%	0.045
Do you think spine fellowship should include both adult and pediatric spine training?			
Yes	54.55%	55.00%	
Maybe	22.73%	15.00%	
No	22.73%	30.00%	0.76
I believe the current method of spine training in both residency and fellowship contributes to poor outcomes of spine surgery			
Strongly agree/agree	31.82%	25.00%	
Neutral	31.82%	35.00%	
Disagree/strongly disagree	36.36%	40.00%	0.15
Approximately how many total spine surgery procedures do your fellows log at the completion of fellowship training?			
0-75	0.00%	0.00%	
76-150	0.00%	5.00%	
151-225	0.00%	5.00%	
226-300	18.18%	40.00%	
301-375	31.82%	20.00%	
376-450	31.82%	10.00%	
>450	18.18%	10.00%	0.30

continued

TABLE II (continued)			
	Orthopaedic Surgery (N = 22)	Neurosurgery (N = 20)	p
Approximately how many MINIMALLY INVASIVE spine surgery procedures do your fellows log at the completion of fellowship training?			
0-10	0.00%	0.00%	
11-20	0.00%	10.00%	
21-30	22.73%	10.00%	
31-40	9.09%	20.00%	
41-50	31.82%	15.00%	
>51	36.36%	35.00%	0.38
Approximately how many NAVIGATION spine surgery procedures do your fellows log at the completion of fellowship training?			
0-10	0.00%	0.00%	
11-20	22.73%	5.00%	
21-30	27.27%	0.00%	
31-40	13.64%	15.00%	
41-50	22.73%	0.00%	
>51	13.64%	70.00%	<0.001
Approximately how many ROBOTIC spine surgery procedures do your fellows log at the completion of fellowship training?			
0-10	54.55%	60.00%	
11-20	0.00%	5.00%	
21-30	22.73%	0.00%	
31-40	9.09%	20.00%	
41-50	13.64%	0.00%	
>51	0.00%	5.00%	0.07

Bold indicates p < 0.05.
 *ACGME = Accreditation Council for Graduate Medical Education.

spine cases by the end of residency, compared with 75.00% of neurological surgery residency PDs who stated that their residents will perform >450 cases by the end of residency (p < 0.001). At the conclusion of residency, 58.33% of orthopaedic residency PDs stated that their residents were confident in diagnosis and investigation of spinal pathology, compared with 100.00% of neurological surgery residency PDs (p < 0.001) (Table I).

Most of the NSGY (70.00%) and orthopaedic surgery (81.82%) fellowship directors agreed that fellowship training should be collaborative between both departments (p = 0.53). At the end of fellowship, NSGY fellowship directors stated that their fellows complete significantly more navigation-guided spine surgeries, compared with orthopaedic spine fellowships (>51 cases performed: 70.00% vs 13.64%, p < 0.001). Fellowship directors in both specialties stated that their fellows log similar volumes of minimally invasive and robotic surgeries (p > 0.05) (Table II).

Ideal Characteristics of Spine Training and Satisfaction with Training

95.83% of orthopaedic residency PDs, 57.15% of NSGY residency PDs, and 90.48% of spine fellowship directors stated that

it is ideal to have a dedicated spine service (p < 0.001). There was significant discrepancy between the responses when asked about the ideal volume of spine surgeries completed by the end of residency. 60.71% of NSGY residency PDs stated that >450 cases should ideally be logged at the conclusion of residency, compared with 0% of orthopaedic residency directors and 26.19% of spine fellowship directors (p < 0.001).

Regarding the time spent on spine surgery, 79.17% of orthopaedic residency PDs felt that ORTH residency has the right amount of time, compared with 7.14% of neurological surgery residency PDs and 19.05% of fellowship PDs (p < 0.001). By contrast, 73.33% of orthopaedic residency PDs felt that NSGY residency has the right amount of time spent on spine surgery, compared with 96.64% of NSGY residency PDs and 73.81% of fellowship PDs (p = 0.11).

If a trainee desires to practice spine surgery in the community, 83.33% of orthopaedic residency PDs said that both orthopaedic and neurosurgical trainees should complete a fellowship, compared with 71.43% and 54.76% of NSGY residency PDs and spine fellowship directors, respectively, who stated that only orthopaedic trainees should do a fellowship (p < 0.001). For spinal

TABLE III Ideal Characteristics of Spine Surgery Training Asked to Both Residency Program and Spine Fellowship Directors*				
	Orthopaedics PDs (%)	Neurosurgery PDs (%)	Fellowship Directors (%)	p
Is it ideal to have a dedicated spine service (as compared to a service which completes spine surgery along with other types of surgery)?				
Yes	95.83	57.14	90.48	
No	4.17	42.86	9.52	<0.001
Approximately how many total spine surgery procedures <i>should</i> residents ideally log at the completion of residency training?				
0-75	8.33	0.00	2.38	
76-150	62.50	0.00	9.52	
151-225	12.50	0.00	16.67	
226-300	12.50	0.00	11.90	
301-375	0.00	17.86	21.43	
376-450	4.17	21.43	11.90	
>450	0.00	60.71	26.19	<0.001
In terms of time spent on spine surgery training, do you believe current <i>orthopaedic surgery residency</i> training in the United States has				
Too much time spent on spine surgery	12.50	0.00	0.00	
Right amount of time spent on spine surgery	79.17	7.14	19.05	
Inadequate time spent on spine surgery	8.33	89.29	80.95	<0.001
In terms of time spent on spine surgery training, do you believe current <i>neurosurgery residency</i> training in the United States has				
Too much time spent on spine surgery	26.67	3.57	21.42	
Right amount of time spent on spine surgery	73.33	96.64	73.81	
Inadequate time spent on spine surgery	0.00	0.00	4.76	0.11
If a trainee desires to practice <i>spine surgery in the community</i> , I believe that he/she should complete a spine surgery fellowship before entering spine surgery practice.				
Yes—for orthopaedic trainees only	12.50	71.43	54.76	
Yes—for neurosurgery trainees only	0.00	0.00	0.00	
Yes—for both	83.33	14.29	45.24	
No	4.17	14.29	0.00	<0.001
If a trainee desires to perform <i>spine deformity surgery</i> , I believe that he/she should complete a spine surgery fellowship before entering spine surgery practice.				
Yes—for orthopaedic trainees only	8.33	3.57	4.76	
Yes—for neurosurgery trainees only	0.00	0.00	0.00	
Yes—for both	91.67	96.43	95.24	
No	0.00	0.00	0.00	0.99

Bold indicates p < 0.05.
*PD = program director.

deformity, orthopaedic PDs (91.67%), NSGY PDs (96.43%), and fellowship directors (95.24%), all agreed that a spine fellowship should be pursued (p = 0.99) (Table III).

There was a similar level of satisfaction between residency PDs and fellowship directors regarding the current spine training model (satisfaction: 54.17%, orthopaedic; 42.86%

TABLE IV Satisfaction with Spine Training Model and Future Direction*

	Orthopaedic PDs (%)	Neurosurgery PDs (%)	Fellowship PDs (%)	p
I am satisfied with the current spine training model in United States				
Strongly agree/agree	54.17	42.86	47.62	
Neutral	25.00	32.14	21.43	
Disagree/strongly disagree	20.83	25.00	30.95	0.79
Rather than the current system of training, I believe there should be a dedicated spine surgery residency following a surgical internship and 1 or 2 yrs of orthopaedic or neurosurgical training				
Strongly agree/agree	37.50	21.43	57.14	
Neutral	16.67	10.71	14.29	
Disagree/strongly disagree	45.84	67.85	28.57	0.02
Training in which of the following skills should be a component of resident training?				
Navigation	54.17	100.00	80.95	
Robotic	41.67	64.29	35.71	
MIS	70.83	96.43	73.81	
None of the above	29.17	0.00	11.90	0.51
I believe surgical simulation could improve spine surgery training				
Strongly agree/agree	70.84	75.00	50.00	
Neutral	20.83	25.00	33.33	
Disagree/strongly disagree	8.33	0.00	16.67	0.10
I believe more competency-based training in spine surgery would be beneficial to trainees				
Strongly agree/agree	70.83	71.43	71.43	
Neutral	20.83	25.00	26.19	
Disagree/strongly disagree	8.33	3.57	2.38	0.83

Bold indicates $p < 0.05$.
 *MIS = minimally invasive spine surgery; PD = program director.

NSGY; 47.62% fellowship, $p = 0.79$). Most of the fellowship directors (57.14%) believed that rather than the current system of training, there should be a dedicated spine surgery residency, which is significantly higher than orthopaedic residency PDs (37.50%) and NSGY residency PDs (21.43%) ($p = 0.02$) (Table IV). These percentages are higher than the 2013 survey responses, although no group reached statistical significance ($p > 0.05$, Table V). All NSGY residency PDs believed that navigation should be a component of a residency training, with 80.95% of fellowship PDs also agreeing ($p = 0.51$) (Table IV).

Comparison Between Orthopaedic and NSGY Fellows

When spine fellowship directors were asked to compare orthopaedic and neurosurgical fellows, neurosurgical trainees were rated as having better surgical skills, surgical confidence, and cerebrospinal fluid (CSF) management, whereas orthopaedic trainees were better at biomechanics and bone metabolism ($p < 0.05$) (Table VI, Fig. 1)

Discussion

This investigation is a 10-year follow-up to a previous survey of orthopaedic surgery and NSGY residency and fellow-

ship directors to examine contemporary spine surgery training. The previous study, conducted in 2013, revealed significant differences in attitudes toward fellowship training between orthopaedic and neurological surgeons, with most in agreement that spine surgery training warrants change. Ten years later, many of these findings remain similar. Ninety-two percent of ORTH residents were found to perform less than 300 spine cases in residency, with over 70% performing less than 150 cases. This drastically contrasts with neurological surgery residency where 75% of trainees perform more than 450 cases. This difference in case volume was highlighted in a recent study examining residency vs. fellowship case volume for orthopaedic spine surgeons. In residency, orthopaedic residents complete an average of 89 spine cases while orthopaedic spine fellows complete an average of 315 spine cases during their fellowship year⁷, thus catching up to many neurological surgery trainees by the conclusion of training. These 2 differing models may each have unique strengths: Neurological surgery provides early and consistent exposure to spine surgery while ORTH gets extensive exposure after a foundation of orthopaedic training is established.

TABLE V A Comparison Between 2013 and 2023 Responses									
	Orthopaedic Residency PDs			Neurosurgery Residency PDs			Spine Fellowship		
	2013 (n = 54)	2023 (n = 24)	p	2013 (n = 42)	2023 (n = 28)	p	2013 (n = 45)	2023 (N = 42)	p
How many months do your residents spend on a dedicated spine surgery service during residency?							—	—	—
0-1	7.41%	4.17%		35.71%	39.29%				
2-4	55.56%	58.33%		7.14%	7.14%				
5-6	29.63%	29.17%		7.14%	10.71%				
7-8	1.85%	8.33%		2.38%	3.57%				
9-10	3.70%	0.00%		4.76%	0.00%				
11-12	0.00%	0.00%		2.38%	0.00%				
>12	1.85%	0.00%	0.75	40.48%	39.29%	0.87			
How many months do your residents spend on a service which performs some spine surgery along with other types of surgery (not a dedicated spine service)?							—	—	—
0-1	22.22%	16.67%		0.00%	0.00%				
2-4	16.67%	25.00%		0.00%	3.57%				
5-6	29.63%	41.67%		6.98%	0.00%				
7-8	9.26%	0.00%		0.00%	0.00%				
9-10	9.26%	8.33%		0.00%	3.57%				
11-12	7.41%	0.00%		4.65%	3.57%				
>12	5.56%	8.33%	0.44	88.37%	89.29%	0.53			
Approximately how many TOTAL spine surgery procedures do your residents log at the completion of residency training?							—	—	—
0-75	28.30%	20.83%		0.00%	0.00%				
76-150	32.08%	50.00%		2.33%	0.00%				
151-225	28.30%	20.83%		0.00%	0.00%				
226-300	7.55%	0.00%		11.63%	0.00%				
301-375	0.00%	8.33%		6.98%	10.71%				
376-450	0.00%	0.00%		16.28%	14.29%				
>450	3.77%	0.00%	0.15	62.79%	75.00%	0.41			
Is it ideal to have a dedicated spine service (as compared to a service which completes spine surgery along with other types of surgery)?									
Yes	96.23%	95.83%		47.62%	57.14%		90.91%	90.48%	
No	3.77%	4.17%	0.93	52.38%	42.86%	0.43	9.09%	9.52%	0.94
Rather than the current system of training, I believe there should be a dedicated spine surgery residency following a surgical internship and 1 or 2 yrs of orthopaedic or neurosurgical training									
Agree	15.09%	37.50%		12.20%	21.43%		45.45%	57.14%	
Neutral	15.09%	16.67%		12.20%	10.71%		18.18%	14.29%	
Disagree	69.81%	45.83%	0.07	75.61%	67.86%	0.59	36.36%	28.57%	0.56
I am satisfied with the current spine training model in the United States									
Agree	49.06%	46.43%		52.38%	42.86%		28.89%	47.62%	
Neutral	37.74%	21.43%		30.95%	32.14%		31.11%	21.43%	
Disagree	13.21%	32.14%	0.08	16.67%	25.00%	0.64	40.00%	30.95%	0.19

Both neurological surgery PDs (100%) and spine fellowship PDs (>55%) believed that spine surgeons should log over 300 cases within their residency, compared with ORTH PDs who believed that ORTH residents should log less than 300 spine surgery cases (>95%) throughout their residency. Both neurological surgery PDs and spine fellowship directors agreed that ORTH residents spend too little time on spine training during residency, with ORTH PDs overwhelmingly believing that their residents spend an appropriate amount of time on spine surgery training. There was relatively uniform agreement that neurological surgery residents spend an appropriate amount of time on spine surgery in residency.

Divergent case volume and time spent on spine surgery also correspond to a significant difference in comfort managing spinal pathology. At the conclusion of residency, just over 50% of ORTH PDs stated that their residents were confident with diagnosis and investigation of spinal pathology, compared with 100% of neurological surgery PDs. The 2013 survey also demonstrated similar findings in case volume, time spent on spine training, and confidence at the conclusion of residency. Despite these discrepancies, demonstrated in 2013 and 2023, spine training between orthopaedic surgery and NSGY remains different.

In addition to opposing opinions on residency training between PDs, there was also discrepancy on the role of

TABLE VI Asking Fellowship Directors How Orthopaedic and Neurosurgery Fellows Compare Across Disciplines

	Orthopaedics % (N)	Neurosurgery % (N)	p
Anatomical knowledge			
Very good/good	77.50 (31)	90.45 (38)	
At level expected	17.50 (7)	7.14 (3)	
Weak/very weak	5.00 (2)	2.38 (1)	0.27
Surgical skill			
Very good/good	60.00 (24)	90.48 (38)	
At level expected	30.00 (12)	9.52 (4)	
Weak/very weak	10.00 (4)	0.00 (0)	0.004
Confidence			
Very good/good	62.50 (25)	88.10 (37)	
At level expected	25.00 (10)	11.90 (5)	
Weak/very weak	12.50 (5)	0.00 (0)	0.01
Interpersonal skills			
Very good/good	85.00 (34)	71.43 (30)	
At level expected	12.50 (5)	21.43 (9)	
Weak/very weak	2.50 (1)	7.14 (3)	0.31
Communication skills			
Very good/good	82.50 (33)	73.81 (31)	
At level expected	12.50 (5)	23.81 (10)	
Weak/very weak	5.00 (2)	2.38 (1)	0.37
CSF management			
Very good/good	25.00 (10)	88.10 (37)	
At level expected	35.00 (14)	9.52 (4)	
Weak/very weak	37.50 (15)	0.00 (0)	<0.001
Biomechanics			
Very good/good	90.00 (36)	38.09 (16)	
At level expected	7.50 (3)	35.71 (15)	
Weak/very weak	2.50 (1)	26.19 (11)	<0.001
Bone metabolism			
Very good/good	82.50 (33)	35.71 (15)	
At level expected	17.50 (7)	38.10 (16)	
Weak/very weak	0.00 (0)	26.19 (11)	<0.001

Bold indicates p < 0.05.
CSF = cerebrospinal fluid.

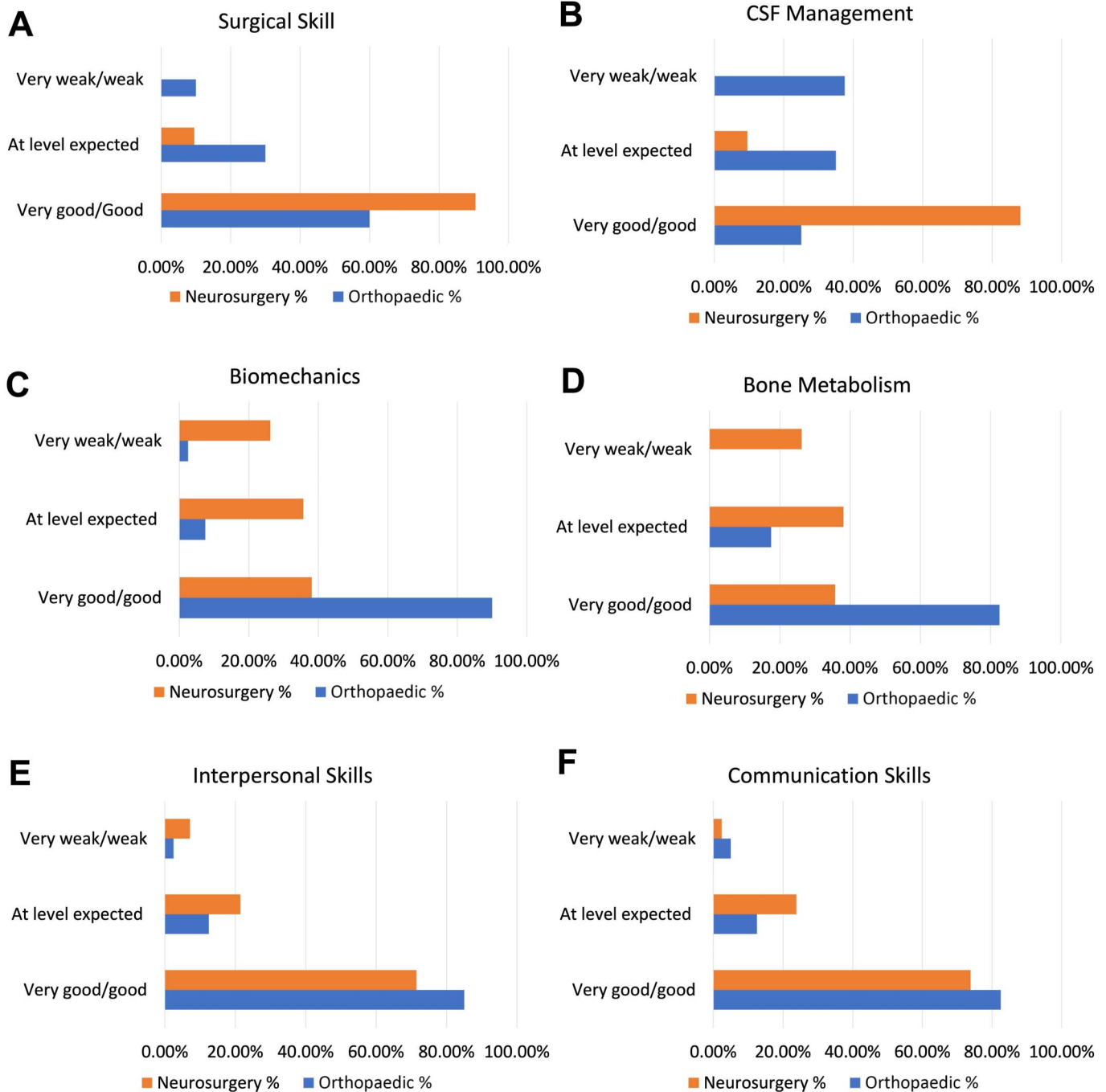


Fig. 1 Rating of skill domains between orthopaedic and neurosurgery spine fellowship trainees.

fellowship training. For trainees interested in community spine practice, 83% of orthopaedic PDs and 45% of spine fellowship directors believed that both orthopaedic and neurological surgeons should perform a spine fellowship, with 71% of neurological surgery PDs believing that only ORTH residents should pursue fellowship training. This contrasted with trainees interested in a spinal deformity practice, where >90% of all respondents believed that residents

should pursue additional fellowship training, regardless of their completed residency program.

One knowledge-based survey regarding spinal deformity principles given to both neurological and orthopaedic surgeons demonstrated that fellowship training increased the accurate response rate among both specialties but that orthopaedic surgeons tended to have a higher correct answer rate compared with neurological surgeons^{8,9}. It is well-documented that spinal

deformity surgery is challenging with a high rate of complications¹⁰⁻¹³. While deformity may be greatly emphasized during orthopaedic spine training, fellowship training drastically improves the knowledge of spinal deformity principles and is essentially mandatory for trainees wishing to practice spinal deformity surgery.

These discrepancies carried over into perceived strengths and weaknesses between neurological and orthopaedic surgeons, with fellowship directors believing that neurological surgeons less commonly had weaknesses in surgical skills, were more adept at CSF management, and were more confident. Orthopaedic surgeons were more often believed to have a better understanding of spinal biomechanics and bone metabolism. One study evaluated academic productivity between orthopaedic and neurological surgeons, determining that spine fellowship training increased academic productivity for orthopaedic but not neurological surgeons and that orthopaedic surgeons tended to pursue a greater number of years of fellowship compared with neurological surgeons¹⁴. Another benefit of spine fellowship training is the financial incentive, at least among orthopaedic surgeons, with one study finding that spine surgery fellowship had the earliest return on investment of any of the fellowship training pathways¹⁵. However, it is unclear whether this is because of the complexity of spinal conditions being performed or whether it is the general pay structure of spine surgery compared with other orthopaedic subspecialties that makes this favorable. Correlating this with return on investment within neurological surgery would also be important and could be an area for further study.

Regarding training methods, 70% of orthopaedic and neurological surgery PDs believe that surgical skill simulation and competency-based models should be used to improve training. Among fellowship directors, 70% agreed that competency-based training should be used; however, only 50% believed that surgical skill simulation training would help improve training quality. Neurological surgeons used significantly more cases with navigation and had a trend toward using more robotic surgery, compared with orthopaedic surgeons. This finding of increased navigation and robotic surgery in neurological surgery is one that has been demonstrated in prior studies¹⁶, although the utility of technology in spine training has been brought up as a “double-edged sword” because of the relative lack of experience with more traditional methods of screw placement¹⁷.

Surgical skill simulation and competency-based training models have shown efficacy across a wide range of surgical and nonsurgical specialties. One study among spine surgeons in Canada used a Delphi method to create a list of cognitive and procedural competency objectives that could be used throughout the country to improve spine surgery training¹⁸. This was also reiterated in an international study that demonstrated “boot camps” before starting fellowship, simulation training, and competency-based objectives could all be easily used to increase the skills of their trainees¹⁹. Competency-based models have been successfully implemented among a variety of other medical and surgical specialties with positive results²⁰⁻²³, as have surgical and procedural skill simulations²⁴⁻²⁸. This presents an important area for improvement both in residency training pathways, to eliminate

discrepancies between the 2 specialties, and during fellowship training, to maximize the ability for independent practice.

Although the 2023 survey introduced novel questions to reflect the changing climate of spine training, several questions were repeated from the 2013 survey to evaluate trends in responses. From 2013 to 2023, neurological surgery increased percentage of residents with greater than 300 cases (86%-100%) while ORTH remained with most residents performing less than 225 cases (89%-92%). Regarding fellowship training, there was a growing trend to suggest all trainees, regardless of specialty, should pursue a fellowship. In 2013, no neurological surgery residency program directors stated that their trainees should complete a fellowship if they desire to practice community spine surgery. However, the 2023 survey revealed that 14% of neurological surgery residency program directors stated both trainees should perform a fellowship.

However, the frustration in the current spine training model remains. In both surveys, less than 50% of all PDs stated that they were satisfied, with a growing number stating that they were dissatisfied (increasing from 23% to 29%). The past decade has seen no attempts to address these frustrations in training, and further research should work toward how spine training can be optimized. Interestingly, in the 2023 survey, most fellowship directors (57%) believed that rather than the current system of training, there should be a dedicated spine surgery residency.

This study had several potential limitations. First, the response rate could not be determined accurately because we are uncertain how many of the publicly available email addresses reached the intended recipient. Second, the opinions of orthopaedic and neurological surgeons in the contrasting specialty may be inaccurate because of insufficient exposure to their training pathway and requirements. Finally, the responses to the surgery were predefined; therefore, other possible impactful responses may have been neglected.

Conclusion

Since 2013, spine surgery training has evolved with novel techniques, yet orthopaedic and neurological surgery training remains different in case volumes and educational strengths. In both 2013 and 2023, nearly 100% of respondents believe that all trainees should complete a spine fellowship if performing spinal deformity surgery. Moreover, the dissatisfaction with spine training continues, with less than 50% of PDs satisfied with the current training model, and there is a growing minority of PDs who believe that spine surgery should have its own residency training pathway. ■

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