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HEALTH SERVICES RESEARCH

Development of a Competence-Based Spine Surgery Fellowship Curriculum Set of Learning Objectives in Canada

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Study Design. Modified-Delphi expert consensus method.
Objective. The aim of this study was to develop competence-based spine fellowship curricula as a set of learning goals through expert consensus methodology in order to provide an educational tool for surgical educators and trainees. Secondarily, we aimed to determine potential differences among specialties in their rating of learning objectives to defined curriculum documents.

Summary of Background Data. There has been recent interest in competence-based education in the training of future surgeons. Current spine fellowships often work on a preceptor-based model, and recent studies have demonstrated that graduating spine fellows may not necessarily be exposed to key cognitive and procedural competencies throughout their training that are expected of a practicing spine surgeon.
Methods. A consensus group of 32 spine surgeons from across Canada was assembled. A modified-Delphi approach refined an initial fellowship-level curriculum set of learning objectives (108 cognitive and 84 procedural competencies obtained from open sources). A consensus threshold of 70% was chosen with up to 5 rounds of blinded voting performed. Members were asked to ratify objectives into either a general comprehensive or focused/advanced curriculum.
Results. Twenty-eight of 32 consultants (88%) responded and participated in voting rounds. Seventy-eight (72%) cognitive and 63 (75%) procedural competency objectives reached 70% consensus in the first round. This increased to 82 cognitive and 73 procedural objectives by round 4. The final curriculum document evolved to include a general comprehensive curriculum (91 cognitive and 53 procedural objectives), a focused/advanced curriculum (22 procedural objectives), and a pediatrics curriculum (22 cognitive and 9 procedural objectives).
Conclusion. Through a consensus-building approach, the study authors have developed a competence-based curriculum set of learning objectives anticipated to be of educational value to spine surgery fellowship educators and trainees. To our knowledge, this is one of the first nationally based efforts of its kind that is also anticipated to be of interest by international colleagues.
Key words: clinical fellowship, competency-based, curriculum design, medical education, spine, surgical education, teaching.
Level of Evidence: N/A.
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The field of spine surgery has advanced rapidly over the past 2 decades. With new technologies and new procedures, the breadth and scope of the practice of a spine surgeon has become so broad that it can no longer be covered adequately during the course of residency training.[1] Combined with new residency duty hours restriction that are in effect in the United States (U.S.), the United Kingdom (U.K.), and now in Canada, this has led many to question whether residents are truly ready to enter practice upon graduating from surgical residencies,[1–4] and even whether spine surgery should become its own surgical residency.[5]

Sub-specialization fellowships have and continue to play an important role in ensuring that surgeons obtain the highest quality of training so that they may in turn provide exceptional patient care within a specific area of surgery. After graduating from a fellowship, the expectation is that a surgeon will be competent in performing a variety of elective procedures, as well as to manage a multitude of surgical emergencies and complications. However, fellowships are not uniform. Many spine surgery fellowships function on a preceptorship basis, where mentors may have a particular interest in fields such as deformity, trauma, or degenerative disease. This does not necessarily reflect a more general spine practice that fellows may encounter upon entry into independent practice. A survey by Konczalik *et al*[1] demonstrated significant variability in surgeons' self-reported confidence in performing various core procedures following spine fellowship training in Europe. They concluded that "there is a considerable variation in the competency of post-fellowship spinal surgeons in the management of frequently encountered spinal conditions" and raise the issue of "a lack of uniformity in the surgical curriculum".[1] Malempati *et al*[6] recently performed a similar study in Canada surveying spine fellows upon graduation to assess their self-perceived competence at performing 29 key procedures independently. Of those procedures, fellows indicated being comfortable in independently performing 12 of the 29, requiring "a little more training" for 13 procedures, and "some more training" for the remaining 4.

Herkowitz *et al*,[7] through the North American Spine Society (NASS), highlighted the importance of a fellowship educational curriculum among other factors that trainees should consider in selecting a clinical fellowship.[8] To date, there is limited published literature on spine surgery fellowship education and there remains an important need to develop and validate educational curricula including evaluation methods on the acquisition of clinical skills. The establishment of a nationally based education curricula set of learning objectives at the spine surgery fellowship level was the primary purpose of this study. This was considered a key goal toward enhancing education, including research in education. Secondarily, we aimed to determine potential differences among specialties in their rating of learning objectives to defined curriculum documents.

MATERIALS AND METHODS

A list of cognitive and procedural learning objectives pertinent to spine surgery fellowship was generated by a review of the scientific literature. We obtained these objectives by evaluating educational and continuing medical education materials available through training programs, international spine societies, as well as physician surgical accreditation organizations. Objectives were also included on the basis of perceived gaps in training syllabi as deemed appropriate by expert group members. An initial list of fellowship training objectives included 108 cognitive and 84 procedural competency objectives.

A consensus group of 32 academic and community spine surgeons was established through the Canadian Spine Surgery (CSS) Education Committee (Chair author S.P.). This group was composed of neurosurgeons and orthopedic surgeons whose practice consisted of at least 80% spine surgery, and represented national academic and community interest. Table 1 provides further description of the expert group's composition and experience. The expert group defined *a priori* several terms that were used to evaluate the listed objectives (Table 2).

A modified-Delphi expert method was employed and the initial list of training objectives was voted upon anonymously using an online electronic ballot (SurveyMonkey). After each round of voting, learning goals that achieved 70% consensus on a defined rating scale (Table 2) were eliminated, transferred to the comprehensive fellowship curriculum, or to the focused/advanced fellowship curriculum.[9] Those that failed to reach consensus were discussed and revised before being submitted to the next round of voting, until a 70% consensus agreed to the modification. A maximum of 5 rounds was agreed upon before the commencement of ratification. Once all objectives were assigned to their respective subcategory, the expert group ratified curricula documents as a whole.

Statistical analysis was performed by a biostatistician (J.C.V.) using SAS v9.4 (Cary, NC). Between our neurosurgical and orthopedic respondents, we compared the distribution of surgical practice type, fellowship/program director status, and geographic region of practice by province (Fisher's exact test). We also compared years in clinical practice and number of clinical fellows trained (Wilcoxon rank-sum test). We then analyzed for potential differences in how respondents initially rated each cognitive and procedural objective comparing orthopedic with neurosurgical respondents (Fisher's exact test). A grouped analysis of cognitive (*e.g.*, trauma, oncology, etc.) and procedural (*e.g.*, cervical, thoracic, etc.) ratings was also performed comparing specialty background (Bonferroni corrected non-parametric Wilcoxon rank-sum tests looking for a difference in the distribution of responses). We determined potential differences in initial responses comparing cognitive *versus* procedural domains as well as comparing pediatric *versus* adult domains (Bonferroni corrected nonparametric Wilcoxon rank-sum tests looking for a difference in the distribution of responses). Statistical significance was set at $P < 0.05$.

RESULTS

Twenty-eight of 32 expert members (88% response rate) responded to and participated in voting rounds (Table 1). Seventy-eight (72%) cognitive and 63 (75%) procedural

TABLE 1. Demographics Expert Group by Specialty

	Overall $N=28$	Orthopedics $N=17$	Neurosurgery $N=11$	P
Practice, *n* (%)				0.271*
Community	3 (10.7)	3 (17.7)	0 (0.0)	
Combined	3 (10.7)	1 (5.9)	2 (18.2)	
Academic	22 (78.6)	13 (76.5)	9 (81.8)	
Director, *n* (%)				0.700*
Yes	13 (46.4)	7 (41.2)	6 (54.6)	
No	15 (53.6)	10 (58.8)	5 (45.4)	
Province/Region of Practice	28	17	11	0.110*
Years in practice, median (IQR)	16.5 (10.0–25.5)	18.0 (12.0–26.0)	11.0 (8.0–22.0)	0.168†
Number of fellows in last 5 years, median (IQR)	5.0 (1.5–18.0)	5.0 (2.0–12.0)	8.0 (1.0–20.0)	0.575†

Expertise also included spine surgery fellowship program directors and supervisors, surgical educators with education research expertise, and practicing spine surgeons with concomitant leadership roles at Canadian universities, the Canadian Spine Society (CSS), the Canadian Orthopaedic Association (COA), the Canadian Neurosurgical Society/Canadian Neurologic Sciences Federation (CNSS/CNSF), and the Royal College of Physicians and Surgeons of Canada (RCPSC) Committee of Specialties (COS).

IQR indicates interquartile range.

**Fishers exact test.*

†*Nonparametric Wilcoxon rank-sum test.*

competency objectives reached 70% consensus in the first round. By the fourth round, a total of 82 (76%) cognitive and 73 (87%) procedural objectives reached 70% consensus (Figure 1). Fifty-eight percent of the pediatric objectives remained unresolved after 4 rounds of voting. Through consensus agreement following additional group discussion, members recommended the creation of a separate pediatrics curriculum (with recommendation that the 3 initial pediatric cognitive objectives ratified to the comprehensive curriculum appear in both comprehensive and pediatric curriculum documents, and the 7 items recommended for initial inclusion in the focused/advanced curriculum be transferred over to the pediatric curriculum). Five additional pediatric cognitive (communication, informed consent, and prognosis) and procedural (infection, trauma) objectives were also developed and recommended to be included in the pediatric curriculum based upon discussion. During voting rounds 2 through 4, 5 adult cognitive objectives were reworded and 1 additional cognitive item was developed and ratified to the comprehensive curriculum.

Excluding the pediatric objectives discussed above, there were 5 cognitive and 7 procedural objectives that did not reach 70% consensus after 4 voting rounds (Table 3). There was consensus agreement that all 12 remaining objectives should be included and not excluded in curriculum documents and therefore the final round ratified these remaining objectives to the appropriate curriculum category using a majority vote (>50% consensus; Table 3). Final curriculum documents developed include a general comprehensive curriculum (91 cognitive and 53 procedural objectives; Appendix A, http://links.lww.com/BRS/B55), a focused/advanced curriculum (22 procedural objectives; Appendix B, http://links.lww.com/BRS/B55), and a pediatrics curriculum (22 cognitive and 9 procedural objectives; Appendix C, http://links.lww.com/BRS/B55).

Statistically, there were several interesting observations when evaluating initial survey replies comparing respondents by background specialty training (Table 4). In some neurologic-related cognitive objectives (*e.g.*, recognition of nonsurgical and surgical spinal cord syndromes, medical management in spinal cord injury, oncologic conditions

TABLE 2. *A Priori* Definitions for Rating of Cognitive and Procedural Learning Objectives

Learning Objectives Rating Scale—*A Priori* Definitions	
A training objective not appropriate for fellowship curriculum	An objective that is not appropriate at the fellowship level for the training of a Spine Surgeon in Canada and/or a competency that should have been attained during medical school or surgical residency.
A training objective appropriate for a comprehensive fellowship curriculum	Objective appropriate and considered an important competency to be gained during spine fellowship training.
A training objective appropriate for a focused/advanced fellowship curriculum	Objective considered advanced by nature of the cognitive or procedural competency to be achieved and will required a focused exposure at a tertiary/quaternary center and/or specialized advanced surgical skills courses to acquire competency.

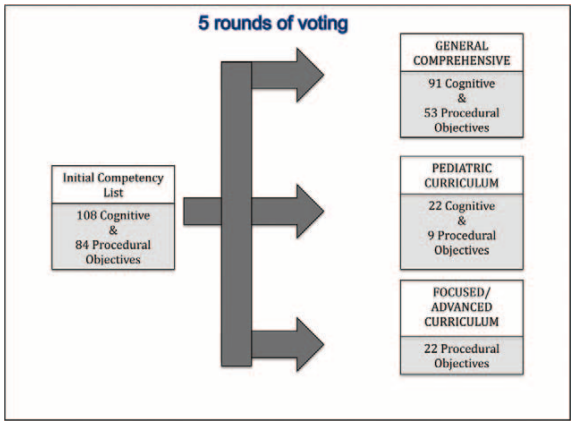

Figure 1. A flow map demonstrating the results of Expert Consensus voting in the development of Fellowship Curricula Set of Learning Objectives. Workflow demonstrating the creation of 3 separate curricula using the Delphi method.

including those involving neural tissues), respondents of neurosurgical background were more likely to recommend these objectives as either not appropriate for fellowship training (*e.g.*, should be acquired during residency training) or for inclusion in the general comprehensive curriculum. Orthopedic respondents, however, were more likely to initially recommend inclusion of objectives into either the general comprehensive or focused/advanced curriculum. This trend direction comparing specialty background was also observed with grouped analyses of cognitive objectives (Table 5, oncology/vascular ($P = 0.034$) as well as degenerative spine ($P = 0.033$) areas).

A similar pattern was also observed for some individual procedural objectives as well, for example, those relating to the use of operative magnification or navigation, select cervical spine procedures, and procedures managing primary neural tumors (Table 4, $P < 0.05$). This was also consistent with grouped analyses of procedural objectives (Table 5, cervical spine ($P < 0.001$), and oncology ($P = 0.035$)).

In general, respondents of both specialties were more likely to recommend the inclusion of procedural (*vs.* cognitive) as well as pediatric (*vs.* adult) related objectives on their initial survey reply for inclusion in the focused/advanced category ($P < 0.001$). During the final round of voting on 12 remaining objectives, there was a difference comparing neurosurgical with orthopedic response in cognitive competency relating to spinal vascular conditions ($P = 0.05$) and procedural competency relating to spinal osteotomies ($P = 0.02$). For both these competencies, orthopedic surgeons tended to recommend inclusion in the focused/advanced category when compared with neurosurgeons who tended to recommend inclusion into the general comprehensive category.

DISCUSSION

Two recent trends have motivated the development of a competence-based spine surgery fellowship education curriculum in Canada. Firstly, surgical residency training in North America is rapidly changing. With a successful legal challenge in Quebec, many provinces are now looking to implement more stringent work hour restrictions within their residency-training programs (Arbitration Board: Canada, Province of Quebec. McGill University Health Centre and Association des Resident de McGill Arbitration Award, June 7, 2011). Similarly, after the implementation of the latest resident supervision and duty-hour regulations from

TABLE 3. List of Cognitive and Procedural Objectives Requiring Majority Ratification on Final 5th Voting Round

Cognitive Objectives
Recognize and demonstrate knowledge of the surgical treatment required to manage spino-pelvic dissociation.
Demonstrate the ability to recognize spinal vascular malformations, such as arteriovenous malformations, dural arterio-venous fistula, and hemangiomas, including knowledge of treatment options for spinal vascular conditions.
Recognize and know how to facilitate the treatment of common pain conditions that may be referred to spine surgeons, such as fibromyalgia, complex regional pain, and chronic neuropathic pain.
Demonstrate the ability to assess a patient's return to work and physical activities, including the ability to manage the medico-legal requests made by third parties.
Demonstrate knowledge of concepts specific to research in the spine, both surgical and nonsurgical conditions. These include the development of a research question, hypotheses and specific aims, knowledge of study design, interpretation, and critical evaluation of the spine literature.
Procedural Objectives
Demonstrate the ability to perform a cervical disc arthroplasty.
Demonstrate proficiency in managing both sagittal and coronal plane deformities of the thoracic spine with instrumentation.
Demonstrate the ability to perform slip or angular reduction for spondylolisthesis and spondyloptosis.
Demonstrate proficiency in the use of minimally invasive spine surgery techniques (*i.e.*, tubular systems).
Demonstrate the ability to perform a XLIF (extreme lateral interbody) and DLIF (direct lateral interbody) in spinal disease.
Demonstrate proficiency in performing a vertebral augmentations procedure such as vertebroplasty and kyphoplasty for spinal disease.
Demonstrate proficiency in spinal osteotomies, including Smith–Peterson, pedicle subtraction osteotomies, and vertebral column resection osteotomies.

TABLE 4. Initial Survey Replies—Differences in Item Response Comparing Specialty Background
Cognitive Objectives
Identify nonsurgical spinal cord syndromes, including amyotrophic lateral sclerosis, demyelinating conditions, and systemic diseases affecting the spine, and appropriately refer them to appropriate nonsurgical specialists ($P = 0.005$).
Recognition of the importance of maintaining mean arterial blood pressures in the setting of acute cervical spinal cord injury ($P = 0.022$).
Identify syndromes of spinal cord injury, including complete transverse injury, anterior cord injury, Brown–Sequard injury, central cord injury, posterior cord injury, cruciate paralysis, syringomyelia, conus syndrome, and sacral sparing ($P = 0.03$).
Be competent in establishing a diagnosis of neoplastic spine disease; specifically the early provisional diagnosis of a primary vertebral extra-dural tumor *versus* metastatic tumor as well as those intra-dural (intramedullary/extramedullary) tumors that affect the spine based on clinical presentation and imaging ($P = 0.012$).
Being competent, based on the final staging including histological verification, in demonstrating knowledge of the appropriate medical and surgical treatment for spinal tumors and assembling/coordinating the appropriate multidisciplinary medical team required for patient care ($P = 0.023$).
Demonstrate the ability to recognize and classify spinal instability in spine oncology (*e.g.*, grading systems such as Spine Instability Neoplastic Score [SINS], $P = 0.023$).
Recognize the causes of and demonstrate knowledge on the appropriate management of for pediatric patients presenting with back pain ($P = 0.015$).
Demonstrate the ability to assess skeletal maturity and associated risk of deformity progression in pediatric spinal disorders ($P = 0.001$).
Demonstrate knowledge on the recommended medical management of infectious lesions of the spine, such as vertebral osteomyelitis, discitis, and epidural abscesses ($P = 0.03$).
Demonstrate knowledge of the indications as well as appropriate surgical procedures required in the management of spinal infections ($P = 0.016$).
Demonstrate the ability to use evidence-based medicine decisions when making recommendations regarding operative *versus* nonoperative treatment of the degenerative spine ($P = 0.005$).
Demonstrate proficiency in the diagnosis and knowledge of medical and surgical management for degenerative disc disease, including neurologic effects such as radiculopathy, neurogenic claudication, and cauda equina syndrome ($P = 0.006$).
Procedural Objectives
The use and application of Gardner–Wells tongs for traction ($P = 0.03$).
Utilizing magnification including a microscope and/or loupes for spinal surgery ($P = 0.016$).
Techniques to maintain cervical spine precautions during prone positioning (*i.e.*, Jackson table with Mayfield pins and adaptor) $P = 0.05$.
Demonstrate the ability to carry out both anterior and posterior c-spine approaches ($P = 0.05$).
Demonstrate the ability to properly place upper cervical sub-laminar wires ($P = 0.05$).
Demonstrate the ability to perform upper cervical instrumented stabilization procedures, including the ability to insert C2 pars screws, C1–2 (Magerl) trans-articular C1–2 screws, and the Harms/Goel (*i.e.*, C1 lateral mass and C2 pars/pedicle screw/rod) technique for the management of upper cervical spine disorders ($P = 0.01$).
Demonstrate proficiency in multilevel posterior laminectomies with and without foraminotomies ($P = 0.05$).
Demonstrate proficiency in performing an occipito-cervical instrumented fusion, including the ability to properly place occipital plates (midline or off midline). $P = 0.05$.
Demonstrate the ability to perform a cervical odontoid screw fixation ($P = 0.05$).
Demonstrate proficiency in the surgical treatment of primary intradural/intramedullary spinal tumors ($P = 0.05$).
Demonstrate proficiency in the use of intraoperative image guided navigation systems (2D, 3D) for spinal disease ($P = 0.05$).
Demonstrate proficiency in spinal osteotomies, including Smith–Peterson, pedicle subtraction osteotomies, and vertebral column resection osteotomies ($P = 0.05$).

the Accreditation Council for Graduate Medical Education (ACGME) in 2011, U.S. trainees are also exposed to fewer clinical encounters throughout their training. The implications with respect to surgical residency education are uncertain, but there has been some evidence that trainees feel less competent upon graduation to perform benchmark procedures.[2–4,10]

Simultaneously, there has been a trend whereby surgical trainees are more likely to pursue subspecialty education.[11] In orthopedics, 90% of graduates in 2011 indicated that they were pursuing sub-specialty training, while 87% of neurosurgery residents have indicated that they are strongly considering fellowship.[12] Fellowships are now the norm rather than the exception in the training of surgeons in North America, and surgeons may be relying more heavily on this training phase to prepare them for independent practice as compared with the past.

Fellowships clearly provide a positive impact on self-reported cognitive and procedural competencies in spine surgery. Konczalik *et al*[1] administered an online questionnaire to the members of AOSpine Europe to assess self-reported competencies of surgeons who had completed a 1-year spine fellowship as compared with those who had not. They obtained responses from 289 members, 28% of whom had completed a spine fellowship. They found a significant difference in the ability of fellowship-trained surgeons to manage spinal deformity, cervical spinal trauma, anterior cervical stabilization, posterior cervical stabilization,

TABLE 5. Initial Survey Item Rating Responses (Grouped Categories)—Median and Inter-quartile Range (IQR) Comparing Specialty Background

Grouped Categories	Orthopedic Specialty Background Median (IQR) for Number of Questions Within Group With a Rating of 1, 2, or 3			Neurosurgery Specialty Background Median (IQR) for Number of Questions Within Group With a Rating of 1, 2, or 3			*P* for Difference* Between Groups
	1	2	3	1	2	3	
Cognitive items							
General	1 (0, 3)	15 (13, 16)	1 (0, 1)	2 (0, 8)	15 (9, 17)	0 (0, 0)	0.183
Trauma	0 (0, 3)	14 (13, 17)	1 (0, 2)	3 (0,12)	15 (6, 18)	0 (0, 1)	0.210
Metabolic	0 (0, 0)	4 (4, 5)	0 (0, 1)	0 (0, 1)	5 (4, 5)	0 (0, 0)	0.195
Oncology/ Vasc.	0 (0, 1)	8 (6, 11)	4 (1, 6)	2 (0, 3)	10 (9, 12)	1 (0, 2)	0.034*
Pediatrics	0 (0, 0)	5 (3, 9)	7 (1, 9)	0 (0, 4)	6 (2, 8)	6 (2, 10)	0.635
Deformity	0 (0, 1)	8 (7, 9)	1 (0, 2)	0 (0, 1)	6 (4, 9)	3 (1, 6)	0.219
Infection	0 (0, 2)	6 (4, 6)	0 (0, 0)	1 (0, 5)	5 (1, 6)	0 (0, 0)	0.278
Genetic	0 (0, 0)	5 (4, 6)	0 (0, 1)	0 (0, 2)	4 (3, 6)	0 (0, 1)	0.758
Degenerative	0 (0, 0)	5 (4, 5)	0 (0, 1)	0 (0, 3)	4 (2, 5)	0 (0, 0)	0.033*
Pain/Rehab.	0 (0, 2)	6 (5, 7)	0 (0, 1)	1 (0, 3)	5 (4, 6)	0 (0, 1)	>0.999
CanMEDS+	0 (0, 3)	4 (3, 6)	0 (0, 2)	2 (0, 3)	4 (3, 6)	0 (0, 0)	0.075
Procedural items							
General	1 (0, 5)	9 (9, 10)	1 (0, 5)	5 (0, 6)	8 (3, 9)	5 (0, 5)	0.375
Cervical spine	0 (0, 0)	16 (13, 19)	6 (3, 9)	1 (0, 2)	18 (18,20)	2 (1, 3)	<0.001*
Thoracic spine	0 (0, 0)	10 (7, 12)	2 (0, 5)	0 (0, 0)	11 (8, 12)	1 (0, 4)	0.995
Lumbar spine	0 (0, 0)	11 (10, 12)	2 (1, 3)	0 (0, 0)	11 (9, 12)	2 (1, 3)	0.270
Pediatrics	0 (0, 0)	1 (0, 2)	6 (5, 7)	0 (0, 0)	0 (0, 1)	7 (4, 7)	0.278
Oncology	0 (0, 0)	3 (2, 3)	2 (2, 3)	0 (0, 1)	3 (3, 3)	2 (0, 2)	0.035*
Miscellaneous	0 (0, 0)	4 (3, 4)	7 (6, 8)	0 (0, 1)	5 (4, 6)	6 (4, 7)	0.301

1 = not appropriate for fellowship curriculum.

2 = appropriate for general comprehensive fellowship curriculum.

3 = appropriate for focused/advanced fellowship curriculum.

**Bonferroni-corrected nonparametric Wilcoxon rank sum tests looking for a difference in distribution of responses. Highlighting indicates the comparisons that are significant. Example of interpretation—for Oncology/Vascular cognitive competencies that had 13 questions, orthopedic surgeons scored a median of 4 of these 13 questions a 3 versus the neurosurgical group that scored a median of 1 of these 13 questions a 3—this was a statistically significant difference in distribution. For the cervical spine procedural competencies, there were statistically significant differences both in the number of questions that were scored a 1 and a 3. Because of the multiple comparisons, a Bonferroni correction was applied.*

+Royal College of Physicians and Surgeons of Canada's physicians competency framework = CanMEDS.

lumbar and thoracic trauma, as well as vascular complications associated with anterior exposures. Interestingly, they also noted a considerable variation in the competency of post-fellowship spinal surgeons in the management of frequently encountered spinal conditions. They felt this was mainly because of a lack of uniformity in the surgical curriculum of fellowships that tended to be preceptor-based and had inadequate regulation of their content.

Through the use of a modified Delphi method, a nationally based consensus group was able to develop core set of spine surgery fellowship education objectives. We created a comprehensive curriculum of 91 cognitive and 53 procedural objectives aimed at a general spine surgery fellowship to guide transition to independent clinical practice. We also developed a focused/advanced curriculum of 22 procedural objectives whose training may require focused exposure at a tertiary/quaternary teaching center. The development of a pediatric curriculum as separate from other adult patient-based training objectives evolved during this study. The group had made the initial decision to survey member opinion on both adult and pediatric training. This decision was made, in part, due to the recognition that some spine surgeons manage both adult and pediatric patients. It became evident through results following initial voting rounds and discussion that apart from a few core pediatric cognitive competency objectives, many of the other cognitive as well as specifically procedural objectives would require exposure in a specialized pediatric training environment. This motivated the creation of a separate pediatrics document.

The majority of competency objectives reached consensus during the first round of voting. However, some objectives required several rounds of discussion and voting. Apart from pediatric considerations already discussed, adult procedural objectives such as spinal osteotomies, spinal injections, and vertebroplasty/balloon kyphoplasty are examples

of those items that generated significant discussion. The group recognized inherent variability in scope of practice of current practicing spinal surgeons that reflect personal professional interests, modern trends toward increasing subspecialization within spine surgery, as well as recognized that some procedures are practiced by physicians from multiple specialties. The group also discussed the specific role a spine surgeon may be expected to have in facilitating the management of patients with chronic pain conditions and discussed whether medical legal and work-related objectives should be formally taught as reflected in an education curriculum. Some items, for example, obtaining informed consent for treatment, were felt by many to be a competency that should be acquired by the end of surgical residency. However, the group also considered it important that at the fellowship level, the proficiency and detail of such a discussion with a patient should be beyond the level of that expected of a surgical resident. This is one example of an objective that was re-worded for further clarity and submitted to subsequent voting rounds.

There were also differences observed during initial survey replies for some objectives comparing orthopedic and neurosurgical respondents. Differences in opinion regarding select neuro-oncology, vascular, cervical spine, and osteotomy objectives, for example, may reflect prior background training.[13,14] The objectives of training for spine set by the Royal College of Physicians and Surgeons of Canada (RCPSC) are different for Orthopaedics and Neurosurgery. An understanding of residency training background by specialty as well as by country of origin is important to consider when delivering curriculum content during fellowship training. Nonetheless, what is important to note is that this study demonstrates how surgeons of different specialty backgrounds can collaborate together and through consensus efforts develop educational content relevant to trainees wishing to pursue a career in spine surgery.

There are several limitations to the present study. The primary aim was to develop a nationally based spine surgery fellowship education curricula set of learning goals. The scope of spine surgery practice in Canada may not be generalizable to some countries. Although we assembled a panel of educators and surgeons with broad national and inter-disciplinary representation in spine surgery, there are differences among nations in scope of practice that is dependent on the types of diseases prevalent, the model of health care delivery, and the model of surgical training. To our knowledge, however, our study is the first to describe the process and development of a spine surgery fellowship education curriculum that addresses an unmet area of need as reflected by limited published spine surgery fellowship literature as well as a recent survey of the Canadian Spine Society membership. The development of competence-based objectives complements recent trends around the world in competence-based surgical education.[8,15–17]

The authors also recognize that future work will be required to validate the developed curriculum among existing fellowship programs in Canada and in other countries. Opportunities to study and harmonize education efforts around the country, including the development of assessment tools for key objectives, may further enhance the quality of education. Developed primarily as an education resource, additional broad stakeholder discussion among educators, trainees, health care providers, and accreditation bodies involved in patient health will be important. There currently is no formal accreditation process for spine surgery fellowship education in Canada. Our developed competency-based curriculum of objectives may serve as a useful foundation for recognition through a pilot diploma program (Areas of Focused Competency) recently implemented by the RCPSC.

In conclusion, our study has bridged a knowledge gap in determining what academic and community spine surgeons consider important objectives for spine surgery fellowship training. Through a consensus-building approach, we present competence-based curricula anticipated to be of interest to the journal readership with scientific work that reflects an international trend in competence-based surgical education.

➢ Key Points

- ❑ The vast majority of residents in both neurosurgery and orthopedic surgery are pursuing fellowships after graduating residency.
- ❑ Fellowships have historically been preceptor-based, and may not necessarily follow a curriculum to ensure a comprehensive knowledge base.
- ❑ Many spine fellows feel that they continue to have some gaps in their cognitive or procedural competencies upon graduating from a spine fellowship.
- ❑ Through a Modified-Delphi consensus approach, a core set of cognitive and procedural spine competencies has been established as an education tool for both trainees and fellowship programs.

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