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EDITORIAL

Training the next generation of spine surgeons: an orthopedic and neurosurgical collaboration with historical precedence

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In this article, Lad and colleagues assessed surgical case logs published by the Accreditation Council for Graduate Medical Education (ACGME) from 2014 to 2019, and reported trends in adult spinal surgery case volume and procedural hours for graduating orthopedic and neurological surgery residents.[1] Case volume was converted to procedural hours by using periprocedural times from the 2019 Medicare/Medicaid Physician Fee Schedule. The results demonstrated that graduating neurosurgical residents logged 6.8 times as many cases and 6.1 times as many procedural hours compared to their orthopedic counterparts.[1] Furthermore, the authors reported significantly higher growth rates for both case volume and procedural hours among the neurosurgery graduates (compared to orthopedics) during the same 5-year period.[1] Although pediatric cases were not included in the analysis, Lad et al. elucidated a notable disparity in spine surgery training between orthopedic and neurosurgery residency programs, which may have important implications for training the next generation of spine surgeons.[1]

Currently, spine surgery training in the US involves completion of neurological or orthopedic surgery residency followed by an optional postgraduate spine surgery fellowship.[2] During residency, trainees in both neurosurgery and orthopedic programs are exposed to subspecialty spine education within their respective fields; however, the level of exposure as well as the length of focused training within the various subcategories of spinal pathology can vary widely.[3] Operative case exposure is one objective measure to assess how neurological and orthopedic surgery residents are provided with opportunities to develop their spine education and the technical skills needed in this demanding subspecialty.[3] Probably due to local competition issues, there have been (largely unsubstantiated) claims that a particular training pathway results in a better trained spine surgeon. For example, numerous frequently visited websites and internet forums compare orthopedic spine surgeons versus neurosurgeons for choosing the right surgeon.[4–8] Claims that "fellowship training" results in a superior surgeon compared with those "only doing a residency" are common.[9]

Despite some adversarial claims found the in lay press, a brief historical review of spine surgery demonstrates notable achievements and contributions from both orthopedic and neurosurgical spine surgeons.[10,11] Furthermore, the surgical management of spinal conditions predates the formal organization of neurosurgery or orthopedic surgery as specialties of medicine.[10,12] Before the advent of neurosurgical or orthopedic training, general surgeons attempted decompression surgery for spinal fractures causing paralysis.[10] The results were very poor and demonstrated high rates of mortality.[10] Caring for injured and wounded soldiers during World War I, with the large volume of neurological and musculoskeletal injuries, provided a catalyst for the ultimate emergence of orthopedic and neurological surgery as subspecialties of general surgery.[13]

Neurosurgeons historically managed conditions resulting in pain or neurological deficit caused by neural impingement of the spinal cord or exiting nerves.[14] This led to increased focus on the management of spinal tumors, disc herniation, spinal stenosis, and other conditions causing neurological signs and symptoms.[14] Many surgical techniques that had been developed for operative management of intracranial pathology were used to treat these spinal conditions.[14] Initially, the need for either spinal fusion or spinal instrumentation for many routinely managed conditions was controversial. As discussed in Maiti et al., an early neurosurgical innovator of spinal fusion techniques was Dr. Ralph Bingham Cloward, who performed his first posterior lumbar interbody fusion for lumbar disc herniation in 1943.[11] This approach was considered provocative, and routine use of lumbar fusion was not widely adopted.[11] Although the anterior approach to the cervical spine was first described by Chipault in a textbook of neurosurgery published in France in 1895,[15] it did not regain acceptance until Dr. Cloward reported his technique for anterior cervical decompression and fusion in 1958.[11,16] Notably, two other spine surgeons, Dr. Robinson of Johns Hopkins Univer-

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sity (orthopedic surgeon) and Dr. Dereymaker of Brussels, Belgium (neurosurgeon), nearly simultaneously reported similar techniques in the medical literature.[11]

Because spinal disorders causing pain and neurological deficit are so common, the management of these conditions became an integral part of neurosurgery resident education. As the outcomes of spinal surgery improved and the variety of conditions managed increased, the volumes of patients undergoing neurosurgical management also increased. As certain degenerative conditions were found to be better treated with the addition of spinal instrumentation and fusion, neurosurgeons gradually acquired skills in spinal instrumentation and fusion.[14] Currently, all neurosurgery training programs in the US teach the spectrum of techniques to effectively manage most degenerative, traumatic, oncological, and deformity conditions. Other aspects of neurosurgical residency training that can benefit spine surgeons include significant experience handling delicate neural tissue, repairing dura mater, and managing critically ill patients in an intensive care setting.[2] Because spine surgery exposure is so widespread through the neurosurgery training experience, neurosurgery spine fellowships are generally reserved for those who seek further education in complex spinal deformity, innovative minimally invasive techniques, or advanced spinal oncology.[2]

The specialty of orthopedic surgery has origins in the management of spinal deformity. The term orthopedics was created by Nicholas André, dean of the Faculty of Medicine of the College de France in 1741 (see Di Matteo et al.).[17] Dr. André combined two Greek words: *orthos* (straight or free of deformity) and *paidios* (children).[17] Early treatments for spinal deformity involved traction, bracing, or casting. In the early 20th century, Dr. Russel Hibbs published pioneering work for spinal arthrodesis techniques to correct deformity (see Tarpada et al.).[12] However, these attempted spine fusions still necessitated prolonged immobilization and casting.[12] In 1955, Dr. Paul R. Harrington, an American orthopedic surgeon, devised the ''Harrington rod'' that resulted in the ability to directly correct spinal deformity and more predictably achieve spinal fusion.[12] Subsequent advances in spinal instrumentation such as the system developed in 1982 by Cotrel and Dubousset permitted further correction of the 3D aspects of scoliotic spine, and was subsequently used for the management of other spinal conditions benefiting from instrumentation and fusion (see Knoeller and Seifried[10] and Tarpada et al.[12]).

The field of orthopedic surgery is very broad, and progressive advances in instrumentation and surgical technique have complicated the goal of mastering all aspects of orthopedic subspecialties during residency. As such, orthopedic residency has evolved toward a training model that provides an opportunity to achieve mastery of the management of common orthopedic conditions, while providing less exposure to more complex subspecialty areas—with the expectation that subsequent fellowship training would be needed to provide mastery of subspecialty areas. Of note, more than 90% of applicants taking the American Board of Orthopedic Surgery Part II examination are fellowship trained.[18–20] In comparison to neurosurgery residency training, orthopedic training can provide a stronger background in bone metabolism, skeletal growth and development, biomechanics of the musculoskeletal system, material science of instrumentation systems, fusion techniques, and management of musculoskeletal injuries in the athlete and the elderly.[2]

Given the historical origins of the specialties of neurological and orthopedic surgery, as well as the differences in the corresponding training programs, it seems intuitive that exposure to spine surgery may be different among orthopedic and neurosurgery residency graduates. This was demonstrated in the present study by Lad and colleagues, with neurosurgery graduates performing favorably compared to orthopedics graduates in terms of adult spinal surgery case volume and procedural hours.[1] However, given the opportunity for an advanced spine surgery fellowship, which many orthopedics residents ultimately pursue, either training pathway is likely to produce spine surgeons with similar readiness for independent practice.[2] In fact, as Lad and colleagues noted in their discussion, "this underscores the importance of fellowship training, particularly for orthopedic surgery residents interested in specializing in the spine."[1] Considering that a spine fellowship is almost universally completed by orthopedic surgeons performing spine surgery, little difference in surgical experience during training ultimately exists between the training pathways. In support of this, Malik and colleagues recently reviewed the 2010–2015 ACGME fellowship case logs for "Orthopaedic Surgery of the Spine."[21] The authors reported that the total number of spine cases logged by each fellow increased from 821 in 2010 to 1134 in 2015 (38.2% increase).[21] Further analysis demonstrated that the greatest variation in case volumes between the 10th centile and 90th centile of fellows was noted for deformity cases.[21] Collectively, this may suggest that after combining surgical experience from both orthopedic residency and fellowship, the case volumes (and probably the procedural hours) would compare favorably with neurosurgical training.

Both training pathways have produced well-trained spine surgeons in the US, with graduates demonstrating a remarkably similar skill set and readiness for independent practice. Upon completion of a neurosurgical residency, a graduating trainee can appropriately evaluate and surgically manage the entire range of common spinal disorders. Fellowship training is generally not required and is usually reserved for trainees seeking further education in complex spinal disorders such as deformity. As is universally practiced, graduating orthopedic residents frequently have not had sufficient exposure during training to manage a range of spinal conditions without additional focused training. As such, a subspecialty fellowship in spinal surgery is usually needed to complete this training pathway, and in some cases, a second fellowship may be pursued to learn appropriate management of the most complex spinal pathology. Therefore, after medical school, the typical duration of training to become a spine surgeon in the US may be either 7–8 years or 5–7 years for neurological or orthopedic surgery residents, respectively, and depends on subspecialty interests (e.g., complex deformity typically requires additional training).

In conclusion, orthopedic and neurological surgeons share a rich history and strong tradition of managing spi-

nal pathology.[10,12] Current leaders in spine surgery include residency graduates from each of these respective specialties. Given the disparity in spine surgery resident exposure highlighted by Lad et al., an early cross-specialty collaboration during residency may offer a more well-rounded educational experience in spine care. In fact, Lad and colleagues suggested that "efforts to address this [gap in training] can take the form of increased collaboration between orthopedic and neurosurgery residency programs."[1] Undoubtedly, training the next generation of spine surgeons is a challenging and critically important endeavor, and both training pathways, either through neurosurgery or orthopedic residency followed by potential additional fellowship, ultimately produce similar results. Whichever pathway one chooses, it is important to continue cross-specialty collaboration and to acknowledge the fraternity of orthopedic and neurological spine surgeons who have pioneered our field.

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Disclosures

Dr. Shaffrey is a consultant for Medtronic, NuVasive, and SI Bone; has direct stock ownership in NuVasive; holds patents with Medtronic, NuVasive, and Zimmer Biomet; and received clinical or research support from the ISSGF.

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Response

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We sincerely thank Drs. Shaffrey and Buell for their review of our study. Their thorough contextualization of our findings within the rich history of spine surgery provides a welcome and necessary supplement to our discussion. In their juxtaposition of the origins of spine surgery within each field, the authors illustrated a qualitative difference between the two types of spine surgeons that our quantitative analysis could not measure. Indeed, neurosurgical

spine care is historically rooted in the management of pain and focal neurological deficits caused by neural impingement, whereas orthopedic spine surgery is rooted in the management of painful conditions resulting from spinal deformity, instability, and biomechanical abnormalities. Thus, the earlier findings of Daniels et al. become more clear; while graduating neurosurgical residents were found to perform more spinal cases overall—probably a reflection of the myriad pathologies causing pain and deficit—orthopedic surgery residents specifically performed more deformity procedures.[1] Our own study, an extension of this prior work, reaffirms these observations. Moreover, although we chose to exclude peripheral nerve–type spinal procedures (neuroplasties, nerve sutures and grafts, transections, etc.) from our analysis to ensure valid comparisons between orthopedic and neurosurgical residents, this omission reinforces the distinction between both fields in terms of scope of practice and approach.

This overriding disparity, however, remains of ambiguous clinical value from a patient-care perspective, especially if the great majority of orthopedic spine surgeons pursue fellowship training. For instance, as Drs. Shaffrey and Buell mention, neurosurgical residents accumulate technical expertise in handling delicate neural tissue and repairing dura; practically, this might suggest improved outcomes or a reduced incidental durotomy rate as compared to orthopedic spine surgeons, who lack this exposure. However, a 2017 retrospective analysis of almost 200,000 patients undergoing common spinal procedures found that the risk of surgical complications, all-cause readmissions, and revision surgery were in fact similar between neurosurgical and orthopedic spine surgeons.[2] Conversely, other studies have demonstrated more granular differences. For example, although the incidence of durotomy during spinal surgery ranges from 1.1% to 1.9%, this complication rate was 5 times higher for lumbar microscopic disc surgeries if the attending surgeon had been involved in fewer than 500 microscopic disc cases before.[3,4] Critically, this underscores the necessity of fellowship training, because increased case volumes directly correlate with improved clinical outcomes.[3] Moreover, this example affirms that for complex spinal techniques—like minimally invasive procedures—where there is a high threshold for competency, fellowship training is warranted even in neurosurgical graduates, as Drs. Shaffrey and Buell suggest.

Furthermore, a spine surgeon's background may influence not only their complication rate, but also their management approach to such complications. In a 2018 survey of 217 spine surgeons, for instance, neurosurgeons were more likely to favor using blood patches for durotomy repair than were orthopedic surgeons.[5] In addition, probably related to the comfort learned from managing cranial neurosurgical operative procedures, neurosurgical trainees are typically more likely to use lumbar subarachnoid drains to assist in the management of CSF leaks through durotomies. Although the clinical impact of these preferences remains unexplored, these examples underscore the limitations of using case numbers and hours as a proxy for spinal expertise, because these values do not capture a trainee's technical decision-making, which appears to be heavily influenced by the type of residency program from which they graduated.

In closing, we again would like to thank Drs. Shaffrey and Buell for their elaboration on the many qualitative differences between orthopedic and neurological surgery as they relate to the historical foundation and modern incorporation of spinal procedures. Indeed, their analysis not only provides an explanation for the continued gap in spinal case volume between neurological and orthopedic surgical graduates, but it also underscores the fact that the nature of spinal cases being performed by both specialties often differs appreciably. Given that greater experience can reduce complication rates, the importance of fellowship training—for all orthopedic surgery graduates, and for those neurosurgical graduates seeking to perform more complex procedures—cannot be overstated. Oftentimes, patients question whether their spinal condition would be best treated by an orthopedic spine surgeon or a neurosurgeon. What has become apparent is that it does not necessarily matter in which field of residency the spine surgeon underwent training. What is needed is a good doctor who operates on patients with good clinical indications, chooses the optimal surgical approach, and performs the surgical procedure with a high amount of clinical expertise. Regardless of the field of residency training, a highly skilled spine surgeon is needed to obtain ideal clinical outcomes. To that end, given the effect that interspecialty training differences may have on exposure and technique, we again emphasize the importance of cross-specialty collaboration as a long-term goal for residency programs to consider.

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