Adjacent Segment Disease of the Lumbar Spine: When Is Surgery Appropriate?

by D. Kojo Hamilton, MD

It is a great concern for a patient to have to undergo spine surgery after failing conservative treatment. In the absence of clear emergent operative scenarios, even with advanced techniques such as minimally invasive spine surgery (performed routinely at UPMC), spine surgery remains daunting to the patient — no matter how many times they require operations.

Pain and disability from compression of nerves via bony overgrowth and/or disc herniation, as well as spinal instability, are the leading reasons patients require spinal surgery. It is very important to have a comprehensive approach to the spine with a close-knit group of providers who value conservative measures short of surgery.

What happens when a fusion is not successful, or when more levels in a spine start deteriorating and cause pain, disability, or even neurological deficits? What is to be done if the levels fail sooner rather than later?

Adjacent segment disease is a term used to describe many complications of spinal fusion, including herniated nucleus pulposus, scoliosis, hypertrophic facet arthritis, vertebral compression fracture, listhesis, and instability. Some of the theories for adjacent segment disease include increased biomechanical stress placed on the disc space adjacent to a fusion, the natural history of disc and spinal joint degeneration from genetic factors, and modifiable factors such as poor bone quality, smoking, and obesity. Several studies have demonstrated that increased motion, disc stress, and joint stress can lead to the above deterioration and manifest clinical symptoms of severe, unrelenting back pain and radiculopathy. On a technical level, it is now well known that decompressing without extending fusion to a mobile lumbar segment

Figure 1. Anterior/posterior and lateral radiographic view of a 72-year-old woman with osteoporosis and six prior lumbar surgeries for degenerative disease. She presents with severe back pain and inability to walk due to radiating leg and groin pain. Imaging shows disruption of posterior spinal elements and listhesis from adjacent segment disease of T12-L1 disc space, which was decompressed with prior surgery, and gross misalignment of spine.

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Chairman’s Message

Innovation: Is It Good or Bad?

Innovation is one of the core missions of the University of Pittsburgh Department of Neurological Surgery. On the surface, innovation is good. However, if we look closely into what innovation means, we must carefully analyze its downstream effect. The Merriam-Webster dictionary defines innovation as “the act or process of introducing new ideas, devices, or methods.” The intention of innovating, particularly as it pertains in medicine, is to produce something that is better than what existed before, or to produce something that is completely novel. However, if something new is produced, how do we know that it is indeed better?

The challenge of innovation is to demonstrate that the innovation — be it a procedure, a drug, or a device — is clearly better than what it intends to replace. This sometimes is very clear, and other times not so obvious. If a new drug or a device produces results that are 10% better but costs double, is that a “good innovation”? If a procedure is “minimally invasive” but its outcomes show greater rates of complication or shorter durability, is that a “good innovation”?

Definitively demonstrating that an innovation is “better” than the original is the gold standard. Defining something as an improvement over the original requires careful and unbiased evaluation. As described in the article by Paul Gardner, MD, on page 4, careful determination of outcomes is critical in demonstrating that a novel surgical approach is better than a previous one. D. Kojo Hamilton, MD, Nduka Amankulor, MD, and Johnathan Engh, MD, also describe innovative approaches to complex neurosurgical problems and define pathways to determine their advantages.

Innovation is woven into the fabric and history of our department. As leaders in our field, it is incumbent upon us to show that the innovations we provide for our patients are “good innovations” and back them up with verifiable data. We therefore strive to demonstrate their positive value. In this era of value-driven care, more than ever, we must be fiscally responsible and patient-centered with the process of innovation.

Robert M. Friedlander, MD, MA
Chairman and Walter E. Dandy Professor of Neurological Surgery
Fluorescent-Guided Brain Tumor Surgery Facilitates Better Resection

by Johnathan A. Engh, MD, and Nduka Amankulor, MD

Standard-of-care therapy for primary brain tumors begins, whenever possible, with maximal safe tumor removal. Current medical evidence suggests a positive correlation between the degree of tumor resection and both overall survival and progression-free survival. For many gliomas, areas of discrete tumor can be interdigitated with more normal white matter, making it difficult to achieve complete radiographic tumor resection.

Fortunately, recent developments in fluorophore-guided surgery are helping make these areas easier to detect during brain surgery. In 2006, a randomized trial of 5-aminolevulinic acid (5-ALA), a fluorescent agent, demonstrated improved extent of tumor removal. Since this time, other agents have become available for investigation during tumor surgery, which is fortunate because 5-ALA remains unapproved by the U.S. Food and Drug Administration.

Fluorescein is a dye agent available in topical, oral, and intravenous forms. The agent has been in clinical use for more than 30 years in the diagnosis of retinal disorders, and intravenous sodium fluorescein was FDA-approved for retinal angiography in 2006. While this agent has been in neurosurgical use for decades, especially for the diagnosis of cerebrospinal fluid leaks, it is just now being used to facilitate glioma microsurgery. When combined with a special microscope light filter (Yellow 560), this agent is particularly helpful for high-grade glioma surgery because the contrast-enhancing component of the tumor (generally the target of high-grade glioma resection) demonstrates yellow-green fluorescence. The customized optics of the microscope allow the fluorescein to work at lower and safer doses than were used in previous iterations. This emerging technique for brain tumor removal was recently trialed at UPMC Shadyside and will become routinely available to our tumor patients there.

After clearance for off-label use of fluorescein was obtained from the innovative practice committee of UPMC, the new technology was utilized on five separate patients with brain tumors. An intravenous dose of fluorescein (4 mg/kg) was administered at the time of anesthesia induction, with the goal of allowing the medication to circulate for an hour prior to dural opening. There were no adverse events noted during this trial. Total or near-total radiographic resection was achieved in all cases (Figure 1). The treating surgeons found the agent to be especially helpful in the removal of high-grade gliomas.

Usually, the only side effect of fluorescein administration is temporary discoloration of the urine. However, potential side effects may include nausea, vomiting, pruritis, urticaria, or in rare cases anaphylaxis with bronchospasm, laryngeal edema, and hypotension. Although none of these side effects were seen during our trial, it is critical to have a dedicated neuroanesthesia team available to address any potential adverse events.

Based on the positive initial experience with this agent, the neurosurgical oncology team at UPMC, headed by Johnathan Engh, MD, and Nduka Amankulor, MD, plans to initiate clinical trials assessing the value of fluorescein in the removal of gliomas, metastases, and even areas of radiation necrosis. This technology is a welcome addition to our brain tumor program.

Figure 1. Case study in fluorescein-guided brain tumor resection at UPMC. A 60-year-old man with diagnosis of glioblastoma, status post-treatment with standard adjuvant therapy for 13 months, develops radiographic relapse with excellent functional status (Karnofsky score 90). The area of relapse is seen on a contrast-enhanced T1 axial MRI scan (panel A). The patient received a repeat awake craniotomy with fluorescein-guided tumor removal. A near-total resection of the contrast-enhancing portion of the tumor was achieved, as shown in panels B (non-contrast-enhanced T1 axial post-op MRI) and C (contrast-enhanced T1 axial post-op MRI). Note the green arrow, which indicates a “tail” of tumor cells that were difficult to visualize under white light (panel D). Under the yellow 560 light filter, the tumor cells were clearly visible, helping to maximize safe tumor removal (panel E).
Outcomes Following Endoscopic Endonasal Cranial Base Surgery: Setting a New Standard of Care

by Paul A. Gardner, MD

Since its inception in 1987, the UPMC Center for Cranial Base Surgery has been a source of medical and surgical innovation and has played a key role in the history of skull base surgery. Treatment paradigms evolved over the decades with an increased focus on quality of life issues, and UPMC remained at the forefront with noninvasive innovations such as the introduction of Gamma Knife® radiosurgery and the development of minimally invasive surgical techniques.

The cornerstone of this new paradigm is the endoscopic endonasal approach (EEA), a minimally invasive surgical approach that avoids many of the morbidities associated with traditional transcranial approaches. Through collaboration between neurosurgeons and otolaryngologists at UPMC and other centers, these approaches to the cranial base have been developed and refined over the last three decades. As with any new approach, EEA was initially met with skepticism. Further refinement of endoscopic techniques and technological advances have addressed the early limitations of EEA, and these approaches have gained wide acceptance as a key part of the skull base surgeon’s armamentarium.

The final phase of a paradigm shift is a critical examination of results. The UPMC Center for Cranial Base Surgery, under the leadership of Paul Gardner, MD, and Carl Snyderman, MD, MBA, is redefining the management of patients with skull base tumors by analyzing its experience and assessing oncological and functional outcomes for endoscopic endonasal surgery. Key publications include oncological outcomes for nonfunctioning and functioning pituitary adenomas and visual outcomes and neurological morbidity for suprasellar meningiomas.

Tumors such as chordomas and craniopharyngiomas have been carefully analyzed, and several large series from the Center have established EEA as the new standard of care for most of these tumors. In addition, the clear advantages of EEA for pathologies such as arthritic pannus at the craniocervical junction have encouraged others to adopt the approach. Endoscopic endonasal surgery has been successfully evaluated and applied in both adults and children with equal success. In addition, our extensive experience with rare lesions, such as cholesterol granulomas, skull base schwannomas, and a variety of other cranial base tumors helps us maintain the highest level of care for all patients.

Complications are an unavoidable consequence of any surgery, but they can be minimized through proper training and adoption of surgical principles. Our critical evaluation of complications such as vascular, cranial nerve, and other brain injuries, as well as the development of intraoperative techniques to avoid such injuries, provide a realistic appraisal of EEA surgery that advances the specialty of cranial base surgery while minimizing complications. Advances in reconstructive techniques following removal of tumors have been critical in avoiding complications such as cerebrospinal fluid leak, and our ENT team, with Dr. Snyderman and Eric Wang, MD, has been proactive in the development, refinement, and dissemination of techniques such as the vascularized nasal septal and inferior turbinate flaps. Despite initially high postoperative leak rates following the resection of complex tumors, we were able to show the safety of operating on the brain through the nose, with no increase in infection rates compared with standard craniotomy.

With a complete range of training in all existing skull base approaches and a very active anatomy program (led by our neurosurgical associate director, Juan Fernandez-Miranda, MD, who has been critical in applying and studying new approaches), the Center is helping to train future skull base surgeons across the globe. As work-hour restrictions place constant limitations on training, new and innovative concepts and models have to be developed in order to safely train the next generation. Studying both the impact of training as well as developing new methods of teaching are key to passing along the techniques and concepts developed by our team.

Looking forward, quality-of-life efforts and further refinement of techniques by Dr. Wang and Dr. Fernandez-Miranda promise to constantly improve sinonasal and neurological outcomes for these approaches. In addition, the concept of the minimally invasive corridor is constantly progressing, with the adoption of other corridors such as transorbital approaches performed with oculoplastic surgeon Tonya Stefko, MD. Our team is well-versed in all approaches to the skull base, both open and endoscopic, and is focused on creating a patient-centered and outcomes-directed approach for the treatment of cranial base problems.
Residency Program Ranked Among Top 10 in Country

The University of Pittsburgh’s seven-year neurological surgery residency program was ranked among the top 10 in the country in a peer review process that included over 17,000 board-certified physicians nationwide. The survey was conducted by Doximity, a Silicon Valley-based national physician network created to help health care professionals grow and collaborate.

“The strength of our busy program lies in the high quality of our trainees and faculty, supported by our excellent infrastructure, including our resident coordinator Melissa Lukehart,” said L. Dade Lunsford, MD, Lars Leksell Professor of Neurological Surgery at the University of Pittsburgh and director of the neurosurgery residency program.

The University of Pittsburgh’s seven-year (PGY 1-7) neurosurgery residency program is internationally renowned as a training ground for exceptional neurosurgeons. Accredited by the UPMC Graduate Medical Education Council, as well as the Accreditation Council on Graduate Medical Education (ACGME), the program focuses on training to maximize medical knowledge, build patient care skills, and provide for practice-based and systems-based learning.

Niranjan, Lunsford Edit Book on Concussion

Ajay Niranjan, MD, and L. Dade Lunsford, MD, are editors of a newly released book, Concussion, about the multimodality management of strategies of mild traumatic brain injury and concussion. Published by Karger, the book is the 28th volume in the publisher’s Progress in Neurological Surgery series, of which Dr. Lunsford is the series editor.

According to the publisher’s website, the volume’s 21 papers “describe the recent advances in the pathophysiology, biomechanics, imaging definition, and management of concussion. Advanced imaging and electrophysiological techniques are being used to help delineate the underlying metabolic and ultrastructural effects of concussive injuries. Papers in this volume review the role of emerging techniques including fMRI, SPECT, PET, DTI, MRS, and MEG, as well as report on multimodality concussion management programs, which offer guidelines for selecting relevant team members, assessing community needs, and implementing management strategies that align with current practice standards.”

Special Lectures and Appearances

Joseph Maroon, MD, was the guest of honor at the Western Neurosurgical Society Annual Meeting in Sun Valley, Idaho, August 16-19.

Peter C. Gerszten, MD, was the keynote speaker at the Annual Congress of the Spanish Society of Radiosurgery in Baiona, Spain, September 25.

Ian F. Pollack, MD, was a visiting professor at the Mayo Clinic in Rochester, Minn., September 3-4.

Raymond F. Sekula Jr., MD, hosted and served as the program director for the Benign Essential Blepharospasm Research Foundation Symposium, held August 16 in Pittsburgh.

Juan C. Fernandez-Miranda, MD, and Paul Gardner, MD, each organized pre-congress courses on October 12 for EANS 2014, the European Congress of Neurosurgery, held in Prague, Czech Republic.

Congratulations

Johnathan Engh, MD, received UPMC’s prestigious Award for Commitment and Excellence in Service (ACES). ACES awards honor UPMC staff whose outstanding actions and achievements demonstrate a commitment to putting patients, employees, members, and community at the center of everything they do.

Parthasarathy Thirumala, MD, was selected to participate in the American Academy of Neurology’s 2014-15 Emerging Leaders Forum.

Michelle Bodnar, RN, CNRN, nurse coordinator for the Center for Cranial Base Surgery, earned CNRN certification through the American Board of Neuroscience Nursing.

Patricia Carlier, neurosurgery nurse coordinator, received the UPMC Physician Services Division’s “You Are a Star” award. The award honors PSD staff whose everyday actions and compassion go above and beyond their job descriptions.

Matt El-Kadi, MD, PhD, received the 50th Anniversary Passavant Foundation Legacy of Caring Award for his contribution to building and improving the neurosurgery program and spine center at UPMC Passavant.

In the News

R. Mark Richardson, MD, PhD, was featured in an August 11 Pittsburgh Post-Gazette article that discussed how deep brain stimulation can help people suffering with severe obsessive-compulsive disorder.
Adjacent Segment Disease
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above or below a fused segment, often to alleviate clinical symptoms of stenosis or herniated disc, will accelerate adjacent segment disease.

Currently, up to 40% of all patients undergoing spine surgery will have evidence of adjacent segment disease within five to eight years. The degree of tolerable disability predicts when surgery is needed. There is a high incidence of failure of conservative measures with adjacent segment disease.

For someone with the diagnosis of adjacent segment degeneration with clinical symptoms, if and when to have surgery is a daunting choice. Neurosurgeons currently do not have clear, universal guidelines for the selection of patients. Each case is different and complicated with both clinical and emotional factors, more so than radiographic considerations.

A few concerns of patients with early onset adjacent segment degeneration include whether their initial surgery encompassed all levels of disease, whether they have engaged in any activities that could accelerate deterioration of their condition, and whether they have any inherent genetic or physiologic reasons for their condition.

So far, beyond modifiable factors such as obesity and smoking, as well as less modifiable factors such as bone quality, studies have shown that the failure of including levels with significant facet degeneration — particularly in the rostral aspect of a diseased joint segment — may accelerate deterioration and lead to adjacent segment disease. The lumbar segment L3-4 tends to be the most common level involved in adjacent level disease, simply due to the fact that it is above and adjacent to the most commonly fused lumbar level, L4-5.

Currently, modes of addressing adjacent segment disease of the lumbar spine include disc removal and extension of fusion, placement of stand-alone cages without fusion, and use of less stiff materials known as dynamic implants.

Each mode has its merits and drawbacks. With disc removal and extension of fusion, the decompensated level is included in the prior construct with a solid graft placed between the vertebral bodies to augment the posterior extension of fusion. This is preferred over posterior extension alone, should there be extensive disc herniation with degeneration. The solid graft or cage can be done from a posterior or lateral approach, more so than the anterior approach.

For frail patients, the use of stand-alone cages above a fused lumbar spine to address adjacent segment disease is most often done from a lateral approach, until biomechanical studies show an improvement in their health. Frequently, when their health and mobility improves, posterior augmentation of the previous fusion is recommended.

Studies using dynamic implants (such as less rigid posterior fusion rods) continue to show promise. However, due to the varying long-term success rates with these implants, it is impossible at this time to judge their benefits over traditional fusion materials. There have not been any clinical studies showing statistically improved functional range of motion of the lumbar spine.

In conclusion, due to the high incidence rate, the discussion of possible adjacent segment disease of the lumbar spine should occur prior to initial surgery. It is also prudent that the surgical plan for correction of adjacent segment disease include discussion of subsequent surgical needs and sagittal alignment of the spine.

Figure 2. Close-up view of anterior/posterior and lateral radiographic view.

Figure 3. Extension of fusion, with need for multiple additional fixation and fusion in thoracic spine due to poor bone quality, and large anterior graft to augment fusion and restore alignment. Both treatments led to improved function and reduced pain.
2014 Congress of Neurological Surgeons: Annual Meeting Presentations

The University of Pittsburgh Department of Neurological Surgery was well represented at this year’s CNS Annual Meeting held in Boston, October 18-22. Following is a list of faculty and resident participation.

Practical Courses
3-D Anatomy (Supratentorial). Course Directors: Fernandez-Miranda JC, Rhoton AL. Faculty: de Oliveira E, Sorenson JM.
3-D Anatomy (Infratentorial). Course Directors: Fernandez-Miranda JC, Rhoton AL. Faculty: de Oliveira E.

Building a Neurosciences Program. Course Director: Toms SA. Faculty: Brosious M, Ecklund JM, Friedlander RM, Pracyk JB, Ratliff JK, Siddiqui AH, Steinberg GK.


Information Technology, the Internet and Social Media Marketing to Enhance Your Neurosurgery Practice. Course Director: Colen CB. Faculty: Amadio JP, Belotte JB, Berg DC, Ragel BT, Rosenbaum BP, Stroink AR, Tompson L, Tomei KL.

Live Surgery Presentation
Expanded Endonasal Endoscopy. Surgeon: Gardner PA.

General Scientific Session
From Kona to Kilimanjaro — A Metaphor for Neurosurgery. Speaker: Maroon JC.

Original Science Programs

Seminars and Forums

Balancing Clinical Research and Individualized Care: The Era of “Personalized Medicine” (Hot Topic Session). Speakers: Lonse RR, Tyler-Kabara EC.


Spanning the Spectrum of Neurosurgery. Authors: Moon K, Albuquerque F, Ducreut AF, Crowley RW, McDougall CG.

Posters

Cost-Effectiveness of Stand-Alone Lateral Lumbar Interbody Fusion (LLIF) versus Transforaminal Lumbar Interbody Fusion (TLIF) for Degenerative Spondylosis with Low Back and Leg Pain Over 2 years. Gandhiokle GS, Shin HM, Chang YF, Tempel ZJ, Gersten PC, Okonkwo DO, Kanter AS.


Initial Experience with iMRI-DBS Targeting of the Subthalamic Nucleus in Parkinson’s Disease. Weiner GM, Shin SS, Wagner DM, Chang YF, Richardson RM.


NVP-BKM120 Potentiates Apoptosis in Tumor Necrosis Factor-Related Apoptosis-Inducing Ligand-Resistant Glioma Cell Lines Via Upregulation of Noxa and Death Receptor 5. Foster KA, Jane EP, Premkumar DR, Morales A, Pollack IF.


Prealbumin as a Predictor for Post-Operative Infection Risk in Spine Surgery. Salvetti D, Tempel ZJ, Grandhi R, Okonkwo DO.

International Training at UPMC Center for Cranial Base Surgery

By Paul A. Gardner, MD, and Carl Snyderman, MD, MBA

The UPMC Center for Cranial Base Surgery is the oldest skull base center in North America. It has been a source of innovation and development of novel approaches to the skull base for more than 25 years. The most recent innovation has been the Endoscopic Endonasal Approach (EEA), developed over the past 15 years, with UPMC playing a leading role.

As a result of this role, surgeons from across the U.S. and worldwide come to observe and participate in research on EEA surgery. Over the past six years, almost 250 visiting clinical observers and research fellows from 45 different countries have traveled to work with UPMC’s cranial base team. In addition, neurosurgeons and otolaryngologists from around the globe have completed clinical fellowships and returned to lead the introduction of these techniques in their respective countries, from Singapore and Australia to the United Kingdom. Our Center has helped train the next generation of skull base surgeons.

Surgical advancement is a continual process with repeated iterations of critical evaluation and small improvements. This is achieved through detailed anatomical studies, the study of clinical outcomes, and collaboration with medical device companies on product development. Visiting research fellows have played a significant role in this, under the direction of Juan C. Fernandez-Miranda, MD, who is associate director of the UPMC Center for Cranial Base Surgery and director of the Surgical Neuroanatomy Lab. Under his tutelage, visiting scholars are able to observe novel approaches in the operating room and translate them in the cadaver lab, gaining insights into anatomy and approaches from the unique endonasal perspective. Eric Wang, MD, the final member of our team, has brought his rhinology expertise and extensive research background to focus on the evaluation of sinonasal outcomes and improving quality of life following EEA surgery.

Several teams of surgeons who have gained expertise by studying at UPMC have continued their development. UPMC experts host courses at fellows’ centers and also reach out via our tele-mentoring program, which provides preoperative advice, intraoperative consultation, and care for international patients.

Programs like this spread the innovations created at UPMC throughout the country and world while allowing visiting surgeons to inject their own skills and knowledge into the refinement of techniques.

Free Online CME
To take the CME evaluation for this issue, visit our education website: UPMCPhysicianResources.com/Neurosurgery.