

cnsq IS THE OFFICIAL NEWSMAGAZINE OF THE CONGRESS OF NEUROLOGICAL SURGEONS

CongressQuarterly

FALL 2025



INNOVATION

A closer look at the evolving future of
NEUROLOGICAL TECHNOLOGIES



CNS

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Award Updates

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Spinal Endoscopy

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EDITOR'S NOTE



Theresa Williamson
Editor



Julie L. Chan
Managing Editor

In this Fall issue of *CNS Quarterly*, we celebrate the bold, forward-thinking spirit that drives innovation and technology in neurosurgery.

David Dornbos and Edjah Nduom introduce our TNT Symposium at the CNS Annual Meeting in Los Angeles—spotlighting the dynamic partnership between industry and organized neurosurgery.

We are thrilled to share the inspiring stories of the CNS Innovator of the Year Award winners and to introduce this year's exceptional finalists. Theresa Williamson and her colleagues from the Neurotech Justice Accelerator at Mass General Brigham (NJAM) explore the concept of *Neurotech Justice*, while Shervin Rahimpour and David Michael Brandman dive into the transformative potential of brain-computer interfaces.

On the frontier of reimbursement for emerging technology, Luis M. Tumialan, Cheerag Upadhyaya, and Joe Cheng share their advocacy efforts to ensure appropriate compensation, while Timothy Wang and Brandon Fox offer perspectives on how medical innovations are reshaping patient care.

Our commitment to technological progress is further underscored by the CNS and the Neurosurgery community's pledge to the *Boston Declaration*—a global collaboration authored by Noor Alesawy, Ramya Reddy, Nicole A. Perez, Piper Tingleaf, Nirav Patel, Wenya L. Bi, Mohammad Ali Aziz-Sultan, Kee B. Park, and Gail Rousseau.

Douglas Kondziolka, Editor-in-Chief of *Neurosurgery*, and Neurosurgery Publications Fellow Danielle Golub explore the potential of machine learning and AI models in neurosurgical research and practice.

This issue also features an update from the CNS Foundation by Lola Chambless; and the latest policy and advocacy developments from the Washington Committee, presented by Alex Khalesi and Charlotte Pineda.

Innovation is not just a transient theme—it's a movement. We invite you to explore how technology is shaping the future of our field, one breakthrough at a time.



CNS

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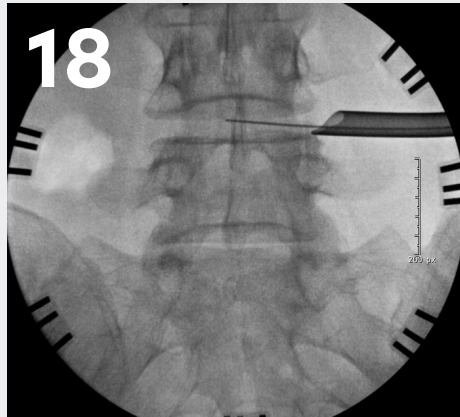
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PRESIDENT'S MESSAGE



Daniel J. Hoh, MD, MBA, FCNS
President, Congress of Neurological Surgeons

Dear Colleagues,

For decades, the Congress of Neurological Surgeons has served as a catalyst for transformative change, driving the evolution of neurosurgical practice and education. In a time when medical technology is progressing at breakneck speed, the CNS remains committed to empowering neurosurgeons through cutting-edge educational offerings, advocacy, and thought leadership.

Our approach to innovation is multidimensional. It begins with education—reimagined for a modern audience. That's why we've built immersive, dynamic educational platforms like those being showcased at the CNS Annual Meeting this fall in Los Angeles. Notably, our TNT Symposium—Transforming Neurosurgery through Technology—will explore the power of partnerships between industry and organized neurosurgery to develop the tools and platforms of tomorrow. The Special Symposium 03: Data Science and AI for Neurosurgeon features hands-on sessions using GPU computing to practice deep learning techniques, building on our successful 2024 workshop. And of course, the finalists for the CNS Innovator of the Year Award are an example of CNS Members at the forefront of innovation, advancing the specialty.

Beyond the Annual Meeting, the CNS maintains a keen focus on evaluating strategies to improve AI initiatives related to neurosurgery through the CNS Innovation Institute. From our Innovation Institute online catalog to live courses like the recent the Neuro Innovate course, presented by the University of Chicago Department of Neurological Surgery and endorsed by the CNS, we work to educate

practicing neurosurgeons on how they can apply these AI tools in their own practice to improve health outcomes. Another example is our virtual spring Artificial Intelligence in Neurosurgery Practical Course, which offers an in-depth exploration of interpretable models to predict clinical outcomes. More than just a technical deep dive, this virtual course serves as a global forum—accessible across geographic and institutional boundaries—where neurosurgeons collaborate, share insights, and shape the tools that will define the next era.

The CNS is also a strong advocate for innovation beyond the operating room. Through our Washington Committee and Washington Office, we actively support legislation that fuels the discovery of life-saving treatments and technologies. Our efforts have helped secure vital funding for brain aneurysm research and pediatric cancer initiatives—investments that lay the groundwork for meaningful clinical breakthroughs.

Of course, none of this would be possible without the expertise and vision of our neurosurgeon volunteers. As researchers, educators, and institutional leaders, the volunteers who serve on the CNS Executive Committee and our program faculty are not only adapting to change—they are leading it. The CNS is proud to be a platform where our volunteers' ideas can take root and grow, ultimately becoming the educational products, clinical guidelines, and policy proposals that move our field forward.

Our collaboration with corporate partners plays a pivotal role in this ecosystem. Grounded in a shared commitment to excellence, these relationships enable us to amplify our efforts, leverage unique

The CNS is proud to be a platform where our volunteers' ideas can take root and grow, ultimately becoming the educational products, clinical guidelines, and policy proposals that move our field forward.

strengths, and bring unparalleled value to CNS members. We are forging partnerships that accelerate progress and broadening the horizons of our profession.

This issue of Congress Quarterly showcases the many ways the CNS and its members are driving the technological advancements that are transforming our field. We check in with past CNS Innovator of the Year Award recipients to see how their work has progressed since winning the award and look ahead at our 2025 finalists who will present their projects in Los Angeles. We also hear from CNS members leading developments in brain-computer interface and neurotech justice efforts, examining the ethical and societal implications of next-generation neurotechnologies. Members of the Joint Coding and Reimbursement Committee dive into advocacy efforts aimed at securing reimbursement for spinal endoscopy. And Dr. Gail Rosseau and her team share a report on CNS's pledge to the Boston Declaration, reinforcing our commitment to global neurosurgical equity and health policy innovation.

Each article in this issue underscores the CNS's central role in not only embracing innovation but also shaping the environment in which it can flourish. Thank you for being an integral part of this journey. I look forward to connecting with all of you in Los Angeles and sharing in the innovations that will redefine the future of our specialty. 🇺🇸

Warm regards,

Daniel Hoh, MD, MBA, FCNS

President, Congress of Neurological Surgeons

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David Dornbos III,
MD, FCNS



Edjah Nduom, MD,
FCNS

CNS Annual Meeting TNT Symposium

Innovation sets neurosurgery apart from other medical specialties, and the Congress of Neurological Surgeons (CNS) serves as the home of neurosurgical innovation. Nowhere is this more evident than at the CNS Annual Meeting—particularly in its flagship innovation event, Transforming Neurosurgery Through Technology, better known as TNT: The Innovation Symposium.

The vocation of neurosurgical practice in the United States remains a relatively young specialty, characterized by continual evolution and growth. Its dynamic adoption of new procedures, exploration of treatments for emerging conditions, and consistent drive to improve patient outcomes distinguish neurosurgery from most other specialties. We strive to instill this spirit of innovation in our trainees to ensure ongoing progress in our ability to improve the lives of our patients.

The CNS's core mission is to enhance health and improve lives through innovative neurosurgical education, advancement of clinical practice, and scientific exchange. Innovation is not limited to devices or surgical procedures—it permeates every aspect of the organization. From employing new teaching techniques and active learning formats to building new platforms for disseminating educational content to the next generation of neurosurgeons, the CNS remains committed to transformative change. This commitment is evident not only at the CNS Annual Meeting but throughout the year via multiple educational programs and leadership initiatives. Equally important has been the dynamic manner in which the CNS partners with industry, building longitudinal relationships to bridge the gap between neurosurgical expertise and technological development, providing resources that improve patient care.



The Transforming Neurosurgery Through Technology (TNT) Symposium was forged out of these partnerships with three primary goals:

1. To convene neurosurgeons focused on advancing the field in a format that encourages engagement with the latest innovations and facilitates dialogue among key opinion leaders.
2. To celebrate achievements and inspire future developments in neurosurgery.
3. To foster collaboration between industry partners and neurosurgeons who drive technological progress.

Crucially, TNT is one of the few CNS Annual Meeting sessions that does not offer continuing medical education (CME) credit, allowing for more open collaboration with industry partners and the presentation of cutting-edge content prior to full regulatory approval.

TNT 2025: The Lifecycle of Innovation

The 2025 TNT Symposium will focus on the “Lifecycle of Innovation.” The event brings together early investigators, startups, and established companies to discuss emerging trends, new devices, and the process through which ideas become reality. The day-long symposium will explore the full innovation lifecycle—from the initial idea to trial to approval to widespread adoption—through four key sessions:

1. Ahead of the Curve (Pre-FDA)

This first session will highlight groundbreaking, early-stage innovations. The journey from concept to prototype to investment requires insight, experience, and a measure of luck. Hearing directly from industry leaders and innovators in the field will not only illuminate the pearls and pitfalls of the process, but will also cover best practices and lessons learned, and highlight current innovations that have not yet hit the market or the FDA.

2. Navigating the FDA (Trial Phase)

The second session will focus on a number of products, industry partners, and individuals that are currently navigating the waters of the FDA approvals process. Whether in a phase III trial, navigating an IDE, or networking back and forth directly with the FDA, the process of carrying a novel innovation from initial concept to FDA clearance requires experience and diligence. A number of industry partners and neurosurgical leaders share their firsthand experiences and offer guidance to others pursuing regulatory clearance.

3. Translating Tech Into Practice

Once regulatory hurdles are cleared, how do new devices achieve widespread adoption? In the second half of our program, we explore strategies for scaling innovation and growing markets, highlighting how young technologies transition from approval to real-world application. Identifying ways to grow the market for a young device is as important as the invention itself and often requires innovative mechanisms to allow the technology to impact and improve as many lives as possible.

4. Lifetime of Innovation

The final session will examine how existing technologies continue to evolve. New devices and drugs provide big shifts in our treatment of neurosurgical patients, but many frameshifts in neurosurgical care come with adapting current technology into new spaces as well. TNT promises to crescendo into this final phase of never settling once you cross the finish line but continuing to strive for excellence and enhanced patient care.

TNT 2025 promises to be a cutting-edge, can't-miss event featuring leaders in neurosurgery, forward-thinking industry partnerships, and insight into the next wave of advancement. We look forward to the CNS community joining the conversation and engaging in this dynamic event.



CNS Innovator of the Year Updates

The Congress of Neurological Surgeons (CNS) Innovator of the Year Award recognizes individuals who have made significant contributions to the field of neurosurgery through innovation. The award, which launched at the 2017 CNS Annual Meeting, acknowledges and celebrates those driving the profession forward through groundbreaking advancements. Award finalists showcase their innovations at the CNS Annual Meeting each year, and members vote to select the winner, facilitating knowledge sharing and collaboration.

We checked in with six past award recipients for an update on their projects:



2017 Winner:
Daniel A. Orringer, MD, FCNS
 NYU Langone Health | New York, NY
Rapid Intraoperative Diagnosis through Stimulated Raman Histology

Being selected as the inaugural CNS innovator award recipient in 2017 represented an incredible honor and key milestone for the team involved in the development of stimulated Raman

histology, a laser-based technology for generating histologic images in minutes in the operating room. Since receiving the award, our NIH-funded team demonstrated that:

- Stimulated Raman histology can be used to create virtual histologic images interpretable by pathologists and AI algorithms (*Nature Biomedical Engineering* 2017).
- Convolutional neural networks can interpret stimulated Raman histologic images to achieve neuropathologist level accuracy (*Nature Medicine* 2020).
- Transformer encoder-based models can forecast relevant diffuse glioma genetic subclassification (*Nature Medicine* 2023).
- A combined stimulated Raman histology- two photon fluorescence imaging platform revealed that 5-ALA induced-fluorescence colocalizes most strongly with tumor associated macrophages, rather than tumor cells (*Nature Biomedical Engineering* 2024).
- Stimulated Raman histology when combined with ultra-rapid droplet digital PCR can directly quantify tumor cell concentration at resection margins and reveal otherwise indistinguishable tumor infiltration (*Med* 2025).

Ongoing translational work will be focused on the development of new technologies with stimulated Raman histology at their core and the direct application of this technology to advancing the surgical care of brain tumor patients.



2018 Winner:
Nirmeen Zagzoog, MD
 University of Toronto, Toronto, ON
Novel Extended Vertebral Registration for Wrong Level Spinal Surgery (NEVER Wrong)

Our optical navigation technology, honored at CNS 2018, has made major strides since. Initially developed to reduce the incidence of wrong-level spinal

surgery at Dr. Victor Yang's Biophotonics and Bioengineering Lab (BBL), this technology demonstrated performance at least ten times faster than existing systems and introduced segmental registration—a major advantage over conventional methods. The system uses machine vision and patient-specific anatomical registration to provide real-time, radiation-free intraoperative feedback. Our virtual trial showed over 94% accuracy using automated detection algorithms, with one detector exhibiting a conservative bias—clinically preferable for avoiding false positives. The technology is now commercialized as the 7D Surgical Navigation System (Orthofix) and is widely adopted for both spine and cranial surgery worldwide.

Since then, I completed the PhD research I had already begun, focusing on the technology's feasibility for lateral skull base surgery, specifically mastoidectomy. The project explored its application in guiding both human and robotic drill operators. Early results suggest machine vision-based guidance may offer precise, non-ionizing navigation in complex skull base terrain, enabling minimally invasive and robotic-assisted techniques.

Dr. Yang, a pioneer in surgical biophotonics, continues to lead BBL across Western University, Western Research Park, and Toronto Metropolitan University. While I currently pursue a Clinical Fellowship in Neurosurgical Oncology and Stereotactic Radiosurgery at Stanford University, my PhD work has since been further advanced by Dr. Yang's team, focusing on integrating robotics into routine workflows and initiating clinical trials to validate its impact across neurosurgical practice.

Update co-authored by **Victor Yang**, MD, PhD, PEng

performance monitoring and a cloud dashboard for remote neuro-monitoring.

Our vision is straightforward – make pupillometry the de facto vital sign for the brain and make every smartphone a tool for brain health monitoring.



2021 Winner: **Samuel Browd, MD, PhD, FCNS**

University of Washington | Seattle, WA
Proprio Paradigm System

Since receiving the CNS Innovator of the Year Award, Proprio has accelerated its trajectory as a leader in surgical navigation and spatial computing.

The award recognized Proprio's groundbreaking Paradigm® system, which uses real-time light field imaging, AI, and computer vision to create a live, data-rich 3D visualization of surgery—replacing traditional navigation tools with an immersive, dynamic operating experience.

In the months since, Proprio has expanded clinical deployment of Paradigm across key neurosurgical and spine centers, generating robust data on safety, accuracy, and workflow efficiency. These results are informing FDA submissions as the company moves toward expanded regulatory clearance. At the same time, Proprio has strengthened its partnerships with leading academic institutions and integrated its platform into a growing number of surgical procedures, enabling precision guidance without the need for radiation or static preoperative scans.

On the technology front, Proprio's AI-driven capabilities have advanced significantly, including improved real-time anatomical segmentation and predictive modeling that augments intraoperative decision-making. This positions the platform not just as a navigation tool, but as a powerful surgical intelligence system.

Commercially, Proprio has seen strong momentum. A recent funding round has enabled rapid scaling of its R&D, clinical, and commercial teams. With increasing industry recognition and strategic partnerships underway, Proprio is poised to redefine surgical visualization and precision.

The CNS award validated Proprio's mission—to revolutionize the surgeon's experience and improve patient outcomes. The company continues to lead the transformation of surgery through a bold integration of AI, computer vision, and spatial computing.



2019 Winner: **Lynn McGrath, MD**

University of Washington/Harborview
Medical Center | Seattle, WA
*Harnessing AI and Smartphones to
Develop the Next Generation of TBI
Diagnostics*

Since earning the CNS Innovator of the Year award in 2019, Apertur, Inc. has transformed PupilScreen from concept to clinically validated, AI-driven technology ready for widespread use.

We have built a research infrastructure consisting of fifteen partner sites across four continents—from Harborview to Kaohsiung, Kathmandu and from NCAA football to IndyCar Racing—collecting data in TBI, stroke, concussion, Alzheimer's and for the optimization of human performance - building one of the largest curated pupillometry datasets.

This research program has resulted in eight peer-reviewed publications since 2022 validating smartphone pupillometry for detection of severe TBI, large-vessel occlusion, cerebral vasospasm, ischemic penumbra and sports concussion.

In Q4 2025 PupilScreen will launch to consumers via our strategic partnership with Wavely Diagnostics. Users will be able to capture, trend, and share quantitative pupillometry data in any environment, with embedded analytics delivering personalized alerts for cognitive



2022 Winner: Brandon Sherrod, MD

University of Utah Health Care | Salt Lake City, UT
Motorized Robotic Closed Cervical Traction

Motorized cervical traction was awarded Innovator of the Year in 2022. The invention was developed to offer a fully motorized solution to bedside and

intraoperative skeletal traction without the need for weights and pulleys. The device incorporates slip prevention technology and real-time force application and displacement measurement. In 2023 the University of Utah Research Foundation filed a US patent application which is currently pending. The project was awarded a grant from the University of Utah technology licensing office to further develop the device, which is currently under beta-phase prototype development at the University of Utah Center for Medical Innovation. The project has led to three peer-reviewed journal publications. In the next 3-5 years, we aim to submit a 510k FDA application.



2023 Winner: Recai Yilmaz, MD

Montreal Neurological Institute and Hospital | Montreal, Canada
Intelligent Operative Surgical Bimanual Skills Monitoring and Feedback

Proficiency in surgical technical skills is essential, especially in high-risk procedures like neurosurgery, where errors can severely impact outcomes.

Our innovation, the Intelligent Continuous Expertise Monitoring System (ICEMS), provided real-time AI assistance during surgery to provide detailed skill assessments, determine a trainee's proficiency, and support the development of bimanual surgical skills more effectively than human instructors in virtual reality training (Scientific Reports, Yilmaz et al. 2024).

The system uses six algorithms in parallel to make decisions five times per second, enabling not only real-time evaluation of surgical performance but also assistance with instrument utilization and the identification of risks related to bleeding and tissue injury. Validation of this innovative system was performed, differentiating trainees based on their bimanual skills in a brain tumor resection task and predicting their year in training (npj Digital Medicine, Yilmaz et al., 2022).

In its current stage, we aim to integrate the ICEMS into real operating room settings. As a first step, we have developed a cloud-integrated platform for intraoperative data collection and assessment (American Journal of Surgery, Yilmaz et al., 2025). Our ongoing work uses this data to develop AI models that predict surgical outcomes during pituitary tumor resections. Preliminary results suggest that certain surgical parameters related to technical skills may correlate with outcomes, such as pituitary insufficiency and the need for hormone replacement.

Looking ahead, AI systems like ICEMS may help detect performance patterns that lead to better results and assist surgeons in adjusting their techniques to minimize errors and enhance patient care. 

2025 Innovator of the Year Finalists

Each year, the CNS presents the Innovator of the Year award to individuals, companies, or programs that demonstrate novel, translatable, and impactful advancements in the field.

Congratulations to the 2025 finalists, whose submissions are detailed below.

AneuScreen+: A Blood-Based Biomarker for Intracranial Aneurysm Management

Vincent Tutino, University at Buffalo

Developed via Neurovascular Diagnostics, Inc., AneuScreen+ is an RNA expression diagnostic for detecting intracranial aneurysms (IAs) and assessing rupture risk. Building on the team's research-use-only platform, AneuScreen, which detects unruptured IAs via blood RNA biomarkers (AUC = 0.82 in independent testing), AneuScreen+ integrates both detection and risk assessment into a single, widely accessible pre-screening tool, empowering clinicians to identify high-risk individuals earlier and informs decisions about imaging and potential intervention. Through this work, Dr. Tutino hopes to introduce a novel biomarker-driven paradigm to IA management, offering a tool that supports risk stratification, imaging triage, and preventive care. This would be a shift toward proactive, precision-based diagnostics, aligning with neurosurgery's evolving emphasis on personalized medicine.

NanoShunt: A Novel Treatment of Hydrocephalus

Cargill Alleyne, Piedmont Augusta Neurosciences

Treatment of hydrocephalus requires the shunting of CSF from the ventricle to the abdomen via a catheter tunneled underneath the skin causing pain and discomfort, disconnection, shunt blockage, migration, occlusion, infection, bowel injury, and revision of the shunt. The NanoShunt product would obviate the need for tunneling by direct disposal of CSF through the scalp. The patent-pending prototype includes the implant (which consists of a mesh atomizer, wick, and receiver coil), a Band-Aid-like patch with a transmitter coil, and an external driver and battery pack. CSF is transferred to the implant via a catheter and is atomized into an ultrafine mist by a NanoMesh atomizer. The fine mist dissipates through the scalp and will likely also be absorbed by the scalp's rich vascular supply, or may be diverted into an air-cavity (e.g. mastoid air cells). Future experiments are planned using an animal model of hydrocephalus.

Vivistim Paired VNS System

Navzer Engineer, MicroTransponder, Inc.

Manufactured by MicroTransponder®, Inc., Vivistim was approved in 2021 with the FDA's Breakthrough Device Designation and is the first and only intervention clinically proven to help chronic ischemic stroke survivors regain two to three times more upper extremity function than high-intensity stroke therapy alone. The Vivistim device is implanted in stroke survivors by neurosurgeons, enabling therapists to use a wireless remote that communicates with the device to pair vagus nerve stimulation (VNS) with high-repetition, goal-oriented functional activities to increase neuroplasticity. This in-clinic Paired VNS Therapy is complemented by self-initiated Vivistim Therapy, which allows stroke survivors to swipe a magnet across the implant to activate vagus nerve stimulation while doing daily activities at home or in the community. The one-year study analysis demonstrates that self-initiated Paired VNS Therapy may facilitate the continued refinement and consolidation of behaviorally relevant activities, resulting in long-term, persistent improvements. MicroTransponder is changing the status quo in the stroke continuum of care, helping neurologists address stroke recovery beyond the acute crisis.

These finalists will present their innovation on the biggest stage in neurosurgery at the 2025 Annual Meeting in Los Angeles, CA, and meeting attendees will have the opportunity to vote for the winner onsite, which will be announced during Wednesday's General Scientific Session. 



Theresa Williamson,
MD, MPH, FCNS



Nachelle Duque, BA



Francis X. Shen, JD,
PhD



Gabriel Lázaro-
Muñoz, PhD, JD,

Neurotech Justice in Action: Preparing for the Future of Neurotech in Society

Advanced neurotechnology is not only saving lives, but it is also challenging how we think about justice, ethics, and what it means to be human. To meet these new challenges, neurosurgical training must evolve. We need future neurosurgeons who can excel in the operating room—and in the communities those ORs serve.

Preparing a New Generation of Surgeon Leaders

At the Neurotech Justice Accelerator at Mass General Brigham (NJAM), we envision a future in which trainees receive interdisciplinary education and mentorship in neurosurgical ethics and the social implications of developments in neuroscience and neurotechnology. We believe that to accelerate neurotechnology's potential benefits to society, we must generate implementable solutions in collaboration with key stakeholders (e.g., patients, research participants, care partners, community members,

clinicians, device manufacturers). By learning from and promoting stakeholders, we can build a reality that is both feasible and responsive. This reality allows us to unfold a new vision for the future; ideas don't transform the world—people acting on them do. NJAM is made possible by a generous grant from the Dana Foundation's new Dana Center Initiative, which supports NJAM as well as Dana Centers for Neuroscience & Society at UCLA/Charles R. Drew University of Medicine and Science (CDU) and Loyola University Chicago.

At NJAM, we are centered on this vision:

"NJAM will play a leading role in improving equitable access to beneficial neurotechnology and in establishing standards to promote responsible societal use of neurotechnology."

How Do We Carry Out Our Mission?

To realize this vision, NJAM utilizes a unique interdisciplinary model: a three-pillared program combining mixed-methods research training in evaluating the ethical, legal, and social implications of neurotechnology research and translation into clinical care, neuroscience in the legal system, and deep community engagement. Each of the three pillars is led by an expert in that field—neurosurgeon and surgical ethics expert Dr. Theresa Williamson, MD; MPH, FCNS, neuroscientist, lawyer, and bioethicist Dr. Gabriel Lázaro-Muñoz, PhD, JD; and law and neuroscience professor Francis X. Shen, JD, PhD—supported by a strong administrative team, the PIs mentor postdocs, graduate students, and undergraduate trainees.

NJAM provides a structured training environment anchored in multi-year postdoctoral fellowships, a summer research training program, and a year-round apprentice program for trainees at different levels.

One of the most inspiring elements of the summer is the Voices in Neurotech speaker series. In a small group setting, trainees meet leaders in neuroscience, neurosurgery, neuroethics, neurolaw, and beyond. These sessions allow for conversations not only about the work these experts do but—just as important—the journeys they took to get there. Personal stories help trainees reflect on the kind of future we want to build with neurotech, and the roles we hope to play.

With the support of the Dana Foundation and partnerships across Mass General Brigham, Harvard, the University of Minnesota, and many institutional partners, we've connected trainees to a broad network and highlighted their work. In June, we held the Neurotech Justice Summit, featuring two panels—one on the ethical challenges of neurotechnology for improving patient care, and the other on the use of developmental neuroscience to change the law (panel recordings are available at neurotechjustice.org). These panels showed our audience—and trainees—how seemingly distant fields intersect through their mutual connection in brain science. With more than 375 registered attendees, the summit blended in-person and online energy.

The summit explored how, in both the clinic and the courtroom, neurotechnology and neuroscience are improving outcomes. In the clinic, neurotechnology is helping physicians uncover covert consciousness in patients. Yet, access to this advanced neurotechnology is inconsistent, as observed by NJAM trainees in their summer research project.

In neurolaw, NJAM is partnering with the Massachusetts General Hospital (MGH) Center for Law, Brain & Behavior (CLBB) and community partner More Than Words to support an Emerging Adult Program (EAP) run by the Suffolk County District Attorney's Office. The EAP provides tailored services for young adults aged 18 to 25 who are involved in the criminal justice system, helping them reintegrate into the community in healthy and productive ways.

More Than Words (MTW) is a “nonprofit social enterprise that empowers young adults ages 16–24 who are in the foster care system, court-involved, homeless, or out of school to take charge of their lives by taking charge of a bookselling business.” NJAM works with MTW to host community consultations related to the EAP. Working with community partners and patient advocates furthers NJAM's mission to make neurotech accessible and responsive to the needs and realities of diverse populations.

A Trainee Perspective

For those of us lucky enough to be summer trainees, NJAM opened our eyes not just to neuroscience, but to how the intersection of technology, law, and ethics shapes lives. This broader lens gave us a strong foundation moving forward and allowed us to uncover passion-driven research. The NJAM training program works because it recognizes that we cannot afford to simply educate ourselves about the technology being created; we must integrate the insights of the patients, families, doctors, lawyers, ethicists, and thinkers who will use them.

NJAM has created a safe environment for trainees not only to learn but to question the status quo and envision a more equitable future. We are encouraged to create aspirations, define timelines, and map the paths we want to walk—both as individuals and as a team shaping the future of neurotech justice.

- Nachele Duque

What Does This Mean for the Future?

Our commitment to neurotech justice is not theoretical. It's active, urgent, and people-centered.

So what's possible? We envision a future where:

- neurotechnology tools are advanced and equitably accessed;
- neurosurgery leadership and training are well-rounded and reflects the diversity of the patients we serve;
- training in neurosurgery is taught in unison with considerations of ethics and justice; and
- interdisciplinary and community collaboration is the norm, not the exception.

To reach this future, we need to continue building partnerships across all levels—from undergrads to postdocs and beyond. It is imperative to train our future leaders within a culture where ethical educational innovations are just as important as technological breakthroughs.

Neurotech justice is not a vision. It's a practice.

We practice it every time we ask better questions, listen harder, and push further. It has shaped each NJAM trainee—and it will continue to shape the world we are building together. ■



Shervin Rahimpour

David Michael
Brandman

Brain-Computer Interfaces: Frequently Asked (and Unasked) Questions

1. What is a brain-computer interface, and how does it differ from other neuromodulatory technologies used in clinical practice today?

A Brain-Computer Interface (BCI) is a device that records brain signals for people with paralysis, and then translates those signals to allow them to control objects in their environment. By decoding real-time brain signals, a BCI allows users—especially those with motor impairments or communication limitations—to control prosthetic limbs, cursors, or speech-generation tools purely through thought. BCIs focus on extracting meaningful information from neural activity to produce tangible, patient-driven outcomes, thus providing opportunities for functional restoration. Fundamentally, a brain computer interface has three components: a sensor (a source of neural signals), an effector (what the user is controlling) and a decoder (the algorithms that bridge the two). Common sources of neural information include electroencephalography, electrocorticography (ECoG), and populations of single units. The field of BCI distinguishes between implantable (i.e., requiring a surgical intervention) vs. non-implantable (i.e., wearable) devices. While the vast majority of BCI research is done with non-implantable devices, the most compelling and consistent demonstrations for restoring function to patients with neurological disorders (i.e. spinal cord injury, brainstem stroke, or neuromuscular disease like ALS) have almost exclusively been using implantable systems.

While the Brain Computer Interface Society provides a definition for BCI technology that is far-reaching, many BCI researchers feel that BCI devices are distinct from traditional neuromodulatory techniques such as Deep Brain Stimulation (DBS) and vagus nerve stimulation (VNS), which deliver electrical stimuli to therapeutically modulate neural circuits. Responsive neurostimulation (RNS) is a bridge between traditional neuromodulation and BCI. However, RNS is designed to suppress pathologic activity, not decode volitional intent or restore communication. Hence, a BCI reads and interprets brain activity, creating a two-way pathway between the brain and external technologies.

2. What are the industry-sponsored clinical trials that neurosurgeons should know about?

After decades of foundational research, ranging from basic scientific labs to first-in-human early feasibility studies (EFS) across multiple

academic medical centers, the field of implantable BCIs is rapidly evolving. Pioneering efforts from groups like BrainGate (Utah array from **Blackrock Neurotech**), along with other academic consortia, have laid the groundwork for today's translational momentum. Multiple industry sponsors are actively conducting or preparing early feasibility studies for implantable BCIs. Here we highlight a subset of companies currently leading in clinical translation.

Synchron has developed a fully-implantable device designed to record motor-related activity from within the superior sagittal sinus, avoiding direct brain penetration. Their SWITCH study reported a favorable safety profile, enabling users to control digital devices, coupled with an eye-tracking device.

Neuralink is pursuing a fully-implantable high-channel-count cortical implant using ultra-thin threads delivered robotically. While their EFS for communication restoration is ongoing and their study has not yet completed, they have shared some ongoing clinical trial results via social media. While their bit-rate demonstrations are striking, peer-reviewed publications have not been reported.

Paradromics is developing a fully-implantable device designed to record from cortical neural populations in a form-factor similar to modern DBS systems. Their current hardware platform allows for four 400-channel cortical modules to be implanted simultaneously (i.e. 1,600 channels), potentially offering the highest neural bandwidth BCI currency in development. Their EFS is expected to begin in late 2025.

Precision Neurotechnology is developing a minimally invasive ECoG based BCI platform. While their primary focus remains in device validation and translation to the intra-operative and sub-acute epilepsy monitoring unit recordings, they have publicly stated they intend to transition toward a fully-implantable BCI system in the future.

3. In a world where BCI development is tech-driven, what role should neurosurgeons play?

Neurosurgeons have a critical role to play – not just as proceduralists for safely and reliably implanting these devices – but as stewards of responsible neurotechnology. Neurosurgeons bring an understanding of brain and functional neuroanatomy, and specialize in selecting the right device for the right patient and for the right indication. Moreover, neurosurgeons must help define ethical and translational boundaries advocating for meaningful outcomes, long-term safety, and equitable

access. We should be guiding clinical trial design, device approval pathways, and post-implantation care models. And just as importantly, we must ensure the patient's voice remains central in a field that could quickly become enhancement-focused. In short, if BCIs are to fulfill their promise, neurosurgeons must not be passengers; we should lead, collaborate, and safeguard the human side of this clinical revolution.

4. What ethical challenges are most pressing in BCI development?

As BCIs move closer to clinical reality, a range of ethical challenges surface—many of them uniquely pressing because these technologies deal with the substrate of thought, identity, and intent. The most pressing and practical questions focus on the devices themselves. In the case of medically refractory epilepsy, neurosurgeons have a sense of the risks and benefits of recommending VNS compared to RNS or DBS. By contrast, the field is still quantifying the risks and of currently available BCI devices. Furthermore, the field must move carefully and thoughtfully on data privacy. Responsive neurostimulators offer a precedent for the field, where patients are trained to upload their personal neural data to the cloud, so that the industry sponsor (Neuropace) and the clinicians can have access to these data to guide clinical care. Moving forward, BCI devices will produce an unprecedented amount of multi-modal and potentially identifiable information. Careful and deliberate decisions will need to be made to ensure that patient confidentiality is respected while ensuring that clinical, scientific, and engineering innovation can proceed in developing next generation technologies to help future patients. For neurosurgeons, these issues are not theoretical. As stewards of these technologies, we must ensure that BCI development centers on patient dignity, transparency, and long-term ethical responsibility and not just technical success.

5. How far are we from being able to prescribe a BCI for patients, and who are the first patients that are likely to benefit?

We are closer than ever to bringing prescribable BCIs into clinical practice. Though all implantable systems remain investigational, momentum is building. Within the next three to five years, we may witness the first regulatory approvals for BCIs designed to restore communication—particularly in patients with locked-in syndrome from ALS, where the clinical need is urgent and the risk-benefit profile is especially compelling. Beyond communication, motor restoration in individuals with spinal cord injury stands out as another compelling use case. Hybrid systems combining BCI with spinal cord stimulation are demonstrating meaningful functional gains, especially when

paired with exoskeletons and neurorehabilitation protocols. While widespread use is still on the horizon, we are entering a transitional era, one in which the first generation of implantable BCIs will likely be offered at specialized centers of excellence. We envision multidisciplinary teams led by neurosurgeons, neurologists, physiatrists, speech language pathologists and occupational therapists collaborating to guide patient selection, implantation and longitudinal care. This model of multidisciplinary collaboration, anchored by neurosurgical leadership, reflects what our field has already achieved in multidisciplinary epilepsy, movement disorder and oncology care, and offers a powerful blueprint for how we will shape the future of restorative neurotechnology.

6. How might BCI reshape the future of neurosurgical training and practice?

BCI technology is poised to significantly reshape the future of neurosurgical training and practice both in the OR and beyond. As BCIs evolve from scientific demonstrations to clinically viable interventions, neurosurgeons will be called on not only to implant these devices, but to understand how they work, and how to best select patients who need them. Training will likely expand to include interdisciplinary competencies: understanding the principles of neural decoding algorithms, working with neural data in real time, and collaborating closely with engineers, data scientists, and rehabilitation specialists. The neurosurgeon of the future may need to be as fluent in informatics and closed-loop systems as they are in anatomy and microdissection. From a practice standpoint, BCIs blur traditional lines between therapeutic, assistive, and even augmentative technologies. Surgeons may find themselves leading multidisciplinary BCI clinics, overseeing not just hardware placement but longitudinal tuning and adaptation of these systems, more akin to managing a neural prosthesis than performing a discrete procedure. Ultimately, BCI challenges neurosurgery to evolve from structural intervention to functional restoration and real-time interface management, expanding the scope of what it means to treat the brain and to interface with the mind. 

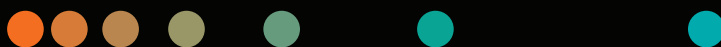
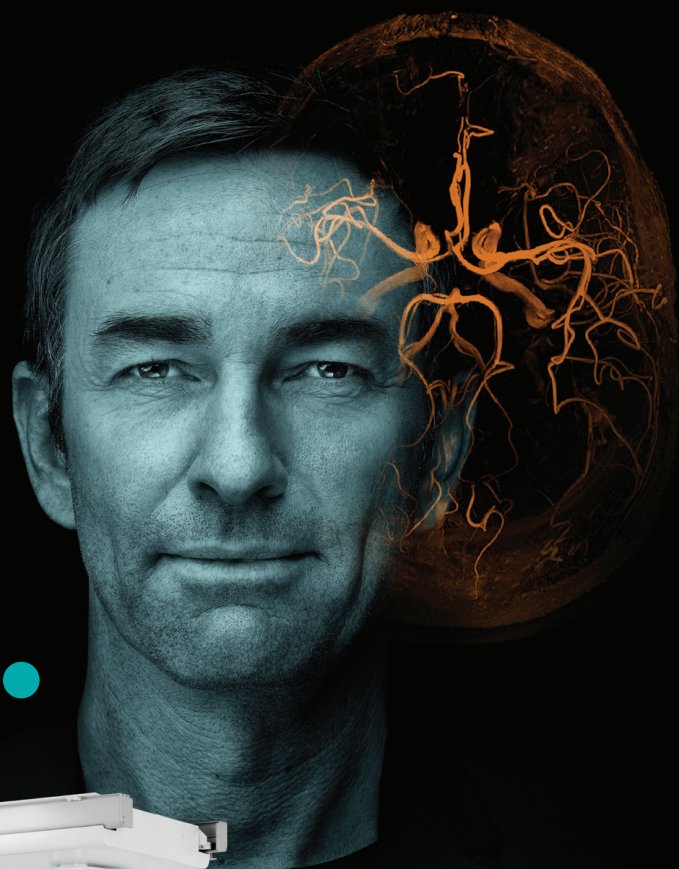
Disclosures:

Shervin Rahimpour is a speaker and consultant for Boston Scientific and Speaker for Neuropace and Abbott.

David Brandman is the proposed study PI for the Connexus brain-computer interface early feasibility study by Paradromics, and an ad-hoc consultant for Globus Medical.

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FCNS

Advocating for Payment for New Technology - Spinal Endoscopy

The recent surge of interest in spinal endoscopy has been met with equal swell in attentiveness for remuneration for spinal endoscopic procedures. Understandably so. For over two decades, spine surgeons have invested time and energy to develop a novel skillset empowered by the recent improvements in visualization and refined endoscopic instruments. But those same surgeons are encountering stiff resistance by commercial payers in the prior authorization process and denial of payments when using the appropriate Common Procedural Terminology (CPT) endoscopic code 62380. Denials for prior authorization and a struggle for payment after the fact blunt the development and expansion of endoscopic techniques for spinal surgery. Our endoscopic spine surgery colleagues find it bewildering that government and commercial payers will not embrace a procedure that offers patients a minimally invasive option for decompression of a nerve root or neural elements. Those same surgeons have asked coding and reimbursement teams what has been done to remedy the situation? However, just like spinal endoscopic techniques, which have been around for decades, advocacy for spinal procedures from neurosurgery's coding and reimbursement team, is nothing new. Nor is the battle for fair remuneration.

As early as 2002, spine surgeons with an interest in endoscopy began advocating for the ability to report and be reimbursed for their services. Those efforts culminated in 2013 with submissions of CPT applications that described spinal endoscopy for lumbar discectomy. These applications went through various iterations with input from

the various stakeholders, leading to the creation of a CPT category I code to allow reporting of endoscopic lumbar discectomy. A CPT code was created and submitted to the American Medical Association (AMA)/Specialty Society Relative Value Scale Update Committee (RUC) queue with a survey of a spinal endoscopic procedure. In 2014, the RUC began the process of transitioning spinal endoscopy from a tracking code to a Category I code. A modest number of 53 physicians responded to the survey. In 2015, after analysis of the survey results, the RUC recommended 231 minutes with 66 minutes of pre-service time, 70 minutes intra-service time to perform the procedure and 30 minutes of immediate post-service time for a same day discharge based on the survey respondents. Two postoperative office visits were also included. The RUC logically compared the surveyed code to similar services, specifically the microdiscectomy (63030) where the work relative value unit (RVU) is rated at 13.18 with 90 minutes intra-service time and the lumbar laminectomy (63047) (RVU=15.37 and 90 minutes intra-service time). After analysis of the surveys and similar procedures, the RUC determined that non-endoscopic microdiscectomies and laminectomies understandably required higher intra-service time and physician work. Therefore, specialty societies recommended, and the RUC agreed that 62380 should be cross-walked to a laparoscopic cholecystectomy (47562). The end result was a RUC recommendation of an RVU of 10.47 for the spinal endoscopy code. Thus, it was that the CPT Editorial Panel established a Category I code (62380) to report endoscopic decompression of the neural elements. Spinal endoscopy appeared to have notched

The 2017 RUC valuation is already complete.
The 62380 code is more than in reach, it is already
in our grasp. Our task is for recognition.



an early victory in 2016. But that apparent victory quickly faded when the recommendations landed on the desk of the Centers of Medicare and Medicaid Services (CMS).

In the 2016, Federal Register surprised the AMA and the specialty societies with their rejection of the RUC recommendations for spinal endoscopy. Even more surprising and confusing was the CMS recommendation to crosswalk spinal endoscopy to the repair of an inguinal hernia (CPT code 49507) adding the comment that both services have similar intensity and identical intra-service physician time. The Joint Coding and Reimbursement Committee, a subcommittee of the Washington Committee, responded in kind with strongly worded response that decompression of neural elements where the possibility of complications and loss of function is completely distinct from the risk involved in an inguinal hernia. Despite the sound argument, CMS ruled to implement 62380 effective January 1, 2017, but without the valuation proposal made by the RUC and defined it to be carrier based. Listed on the 2018 Medicare fee schedule is an unassigned RVU. Instead, the valuation of this service was to be left to the discretion of the local CMS carriers, similar to what we see for codes such as 63044 for revision discectomies at additional levels. Seven years later, 62380 has been relegated to contractor pricing but no specific RVU value by CMS, the body that ultimately sets the RVU values. Compounding this situation further, without a validated RVU from CMS, commercial payers invoke the moniker “experimental and not medically necessary”. Thus, the predicament in which we find ourselves today. So why is the code for spinal endoscopy so challenging as compared to other carrier-based codes, such as 63044 for additional levels of revision discectomy?

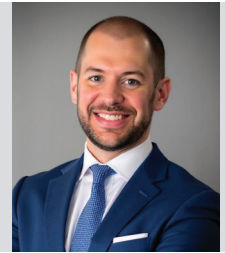
There appears to be something disquieting about the CMS disruption of the rigorous surgical valuation process performed by RUC for the spinal endoscopy code. When a committee made up of 26 different medical and surgical specialties (which make up the AMA's RUC) come together, invest time and resources to apply a validated and methodologically sound process to evaluate a procedure, it should take more than a single governmental agency to unravel the work product of that committee. For spinal endoscopy, the ripple effect has been considerable. Denials and inability to secure prior authorizations have led surgeons to use unconventional coding methods which carry an entire array of unintended consequences. Spinal endoscopy needs a sustainable path forward.

Several endoscopic spine surgeons feel that because the surgical target and objective of the intervention are identical to open and tubular microdiscectomies, that simply using the 63030 CPT code would suffice. Afterall, use of the 63030 code will be met with less resistance and greater likelihood of payment by commercial and governmental payers. Applying that rationale is not without risk,

especially to an audit as it is considered miscoding, or up-coding, to achieve a higher reimbursement than allowed for the service. With a CPT code that describes the work done for an endoscopic spinal procedure, applying the 63030 code would be outside the parameters of best practices. Exposure for claw backs and risk of Medicare fraud is an unneeded stressor for any practice. Our efforts need to be channeled into a viable, appropriate and accurate application of spinal endoscopy codes.

In *The Art of War*, Sun Tzu calls tactics without strategy as the noise before defeat. We need to ask ourselves what is the most cogent and realistic strategy that will allow advancement of our advocacy for spinal endoscopy. We recognize that a chorus of voices are now clamoring for even higher valuations than the RUC's 2017 recommended value. Other voices are insisting on the valuation of additional procedures that are not encompassed by the 62380, specifically cervical decompressions and complete lumbar laminectomies. However, not all these voices come from surgeons. For 62380, only 10.2% of these endoscopic procedures are done in a hospital or facility setting. And for the non-facility endoscopic lumbar discectomies, 66.7% of these procedures are reported by pain management based on the RUC database.

Regardless, the most surefire first step is for a unified voice among all spine societies, both surgical and non-surgical, to advocate for CMS to adopt the RUC recommended valuation of the 62380. Secondly, that same chorus of voices will advocate for commercial payers to include 62380 as part of their coverage determination policies. There should be no greater hurdle for a surgeon to secure a prior authorization for 62380 than 63030. The moniker “experimental and not medically necessary” simply does not apply to a procedure that is now routinely performed hundreds of thousands of times a year around the world. Nor should there be a denial of payment. These are plausible victories that a coordinated effort and unified and consistent voice can achieve. The Joint Section on Disorders of Spine and Peripheral Nerves (DSPN) will focus advocacy efforts on recognition of the RUC valuation of the 62380. Efforts to increase the value of the spinal endoscopy code or to venture off to add additional codes for the various endoscopic procedures that have evolved since the development of the 62380 at this juncture will become unnecessary distractions from achieving the firmest foothold available to spinal endoscopy. The 2017 RUC valuation is already complete. The 62380 code is more than in reach, it is already in our grasp. Our task is for recognition. Once we have secured a firm foothold, the next list of priorities becomes more plausible. To achieve that foothold, we only need to keep in mind that tactics without strategy is the noise before defeat. ❌



Brandon M. Fox, MD,
PhD

There Must Be a Better Way: It's Time to Modernize Noxious Stimulation

On one of my first mornings on the neurosurgery service as a medical student, I followed a resident into the room of a frail, elderly woman who had suffered an aneurysmal subarachnoid hemorrhage ten days prior and remained in a comatose state. She was localizing, but only with robust noxious stimulation. Her bruises told the story of the preceding ten days. I watched the resident, efficient and practiced, escalate intensity when the first attempt didn't yield what he expected to see. He was unruffled; the exam was routine. I understood the rationale, but this scene was deeply jarring. I left the bedside certain there must be a better way.

That morning set me on a path. I learned how structured coma scales gave our field a common language, enabling clearer triage, earlier recognition of decline, and more precise handoffs. Their use professionalized what had been idiosyncratic and made neurologic care more systematic and safer for patients. Use expanded from TBI to other disorders of consciousness and spread worldwide. Yet within that framework, noxious stimulation emerged as the weak point, with accumulated experience showing that manual techniques undermined reliability and caused iatrogenic injury, with consequences that rippled through care.

In residency, problems related to manual noxious stimulation became a daily reality. Stimulation varied across the care team, and exam findings too often reflected technique more than neurologic trajectory, prompting unnecessary workups or delaying escalation. Nurses and trainees experienced moral distress with repeated use of noxious stimulation, and families, already frightened, questioned their loved one's dignity. The ugly reality of visible abrasions, nail-bed damage, and bruising represents the tip of a larger iceberg of inconsistency. Noxious stimulation is essential to successful care, but variability and unintended injury are problems that must be solved.

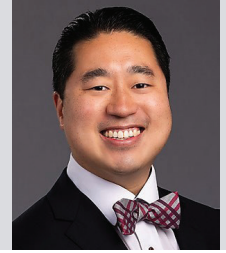
A New Path Forward

My first encounter with noxious stimulation stayed with me. As I learned more, I came to appreciate both the magnitude of the problem and lack of progress toward a solution. I decided to act. At Barrow, we formed parallel clinical-research and device-development teams. Our goal was simple: preserve the exam, change the stimulus. We evaluated injury-sparing, reproducible methods and selected focused transcutaneous electrical stimulation. This method provides immediate onset with fixed intensity, thus minimizing variability and bypassing the injury-prone mechanics of pressure.

We first established safety and dosing in ambulatory volunteers, defining signal parameters and fixed levels for central and peripheral use. We then developed a noxious electrical stimulator that delivers a standardized, constant-current stimulus, so the same patient in the same condition elicits the same exam response regardless of who is holding the device. We are now evaluating the method prospectively in comatose ICU patients in an ongoing clinical trial to characterize its safety and efficacy.

The path forward is clear. We seek to render manual noxious stimulation techniques obsolete. Our patients deserve a stimulus that is precise, reproducible, and humane. If we can remove avoidable variability from the most frequent decision point in neurocritical care, we can tighten the feedback loop between deterioration and intervention, support nurses and families, and give our patients a better chance.

Innovation in neurosurgery isn't always a moonshot. Sometimes it's a better tool for a task we do many times a day. This effort began with a patient who deserved better and continues with a team determined to deliver a humane and reproducible noxious stimulus to routine practice. 

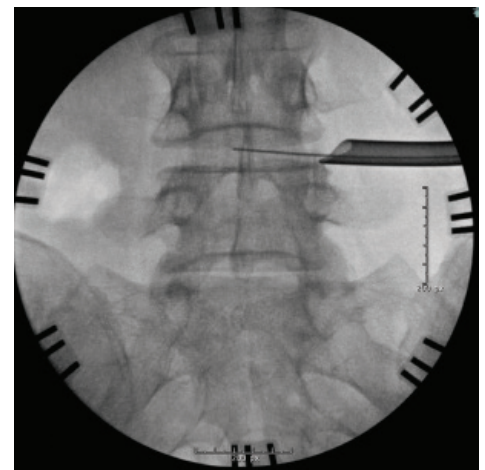


Timothy Wang, MD,
FCNS

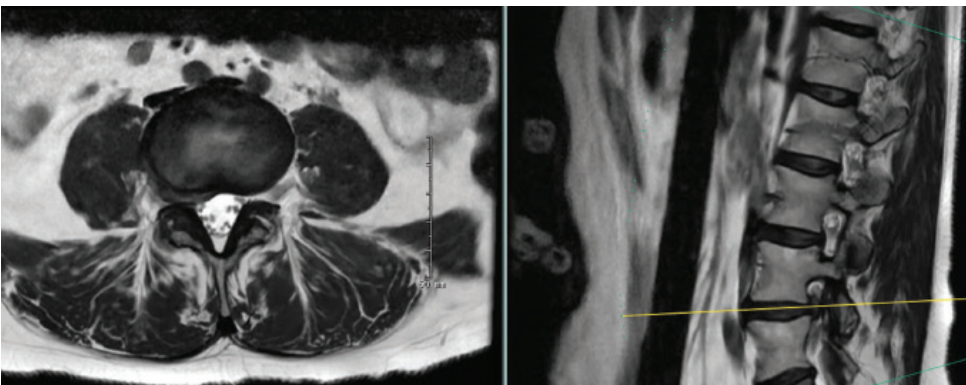
Using Ultra Minimally-Invasive Surgery to Provide Life-changing Spine Care

I had the pleasure of meeting Ms. K, a woman in her mid 50's, in my clinic earlier this year. Several months prior, she had spontaneously developed severe right-sided back and lateral thigh and shin pain that had dramatically worsened in the time prior to our clinic visit. Her imaging demonstrated a sizeable paracentral and far lateral disc herniation on the right side at L4-5. She had obtained an initial opinion at a neighboring tertiary care academic medical center who recommended a fusion as they felt that a total facetectomy was needed to fully decompress the exiting and traversing nerve root. She sought a second opinion with me as she was hesitant to undergo fusion surgery. Given her imaging findings, I felt that a transforaminal endoscopic discectomy would be able to

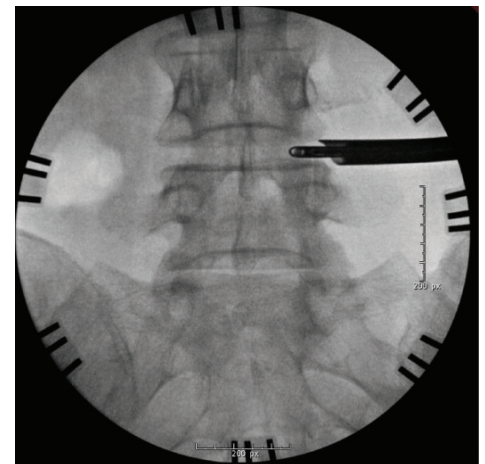
adequately decompress the far lateral component as well as the paracentral component. This ultra minimally invasive surgery would involve a 1cm incision, almost zero blood loss, and would be a same-day outpatient surgery. She decided to proceed with the endoscopic discectomy. Surgical time was 40 minutes and she noticed immediate improvement in pain, postoperatively. Now >3 months out from surgery, she continues to be pain free and is now back to doing all of her previous activities with no disability. Endoscopic spine surgery is an ultra-minimally invasive approach that can treat these disc herniations with a high rate of success with minimal surgical time, minimal blood loss, and high patient satisfaction. In her words, "I have no pain. Thank you for everything." 📧



Intraoperative AP fluoroscopy demonstrating targeting through Kambin's triangle



Preoperative MRI showing far lateral and foraminal right L4-5 disc herniation



Intraoperative AP fluoroscopy demonstrating removal of the disc fragment with pituitary rongeurs

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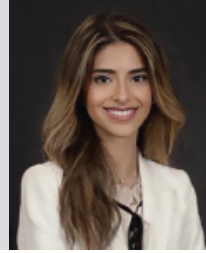


Presented by
Jethro L. Hu, MD

Monday, October 13, 2025 | 12:20 PM PT
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Ramya Reddy



Nicole A. Perez

CNS and Neurosurgery Pledges to the Boston Declaration: Global Health Policy Innovation

“The vision of the Boston Declaration is equitable access to research for all neurosurgeons. Equity in research. Quality in scientific inquiry. Connectivity across barriers. Scholarship for all. That is admirable and inspiring. We support this project and will follow your work.”

—— Professor Dr. Mahmut Gazi Yaşargil and Dianne Yaşargil on the aims of the Boston Declaration, 2025. ——

On April 24, 2025, more than 500 neurosurgical professionals, policy experts, and global health leaders from 100+ countries gathered for the Boston Declaration to discuss the current landscape of global neurosurgery. Attendees heard from more than 50 speakers and celebrated 93 pledges aimed towards future progress in the field. This historic convening, hosted at the Edward M. Kennedy Institute in Boston, included a keynote address by U.S. Special Envoy Joseph P. Kennedy III. He emphasized that “global neurosurgery must move forward with intention,” advocating for a new paradigm rooted in collective action and emphasizing the Boston Declaration’s potential to improve access and affordability of neurosurgery worldwide.

Building on a decade of momentum in global surgery, the Boston Declaration represents the latest milestone to address inequities in neurosurgical care. It draws from a lineage of landmark initiatives, including the 2015 Lancet Commission on Global Surgery, the 2016 Bogotá Declaration on Global Neurosurgery, and the 2024 Peshawar Statement. Together, these efforts intend to map the vast unmet three more than 3.4 billion individuals – nearly half of the world’s population – suffer from neurologic disease. More than 80% of neurologic deaths occur in Low- and Middle-Income Countries (LMICs), where 2024 data show that 29 countries, 14 territories, and one independent state have no practicing neurosurgeons.

Reflecting the complexity of these global disparities, the Boston Declaration convening was organized around five thematic sessions: Challenges, Paradigms, Milieu/Support Pillars, Champions,

and Community/Neurosurgical Societies. The Challenges session highlighted systemic barriers such as insufficient financing, and deficits in workforce, research, and education, with speakers sharing firsthand accounts from conflict zones including Haiti, Ukraine, and Gaza. The Paradigms session explored successful organizational models in global neurosurgery such as Mission:Brain and FIENS. The Champions session showcased progress from low-resource regions like Tanzania, Pakistan, Syria, Sierra Leone, and Bosnia. Finally, the Community session brought together neurosurgical societies across continents – including the American Association of Neurological Surgeons (AANS), the European Association of Neurological Societies (EANS), and the World Federation of Neurosurgical Societies (WFNS) – demonstrating that the call to global neurosurgery is being answered in community.

This spirit of collaboration carried into the Boston Declaration’s pledge framework, where stakeholders—from neurosurgeons and researchers to industry leaders and policymakers—worked closely with the Boston Declaration Steering Committee over six months to craft specific, measurable, and actionable pledges that will be tracked over the next one-, three- and five-year intervals. These commitments reflected the diversity of the field and its challenges, ranging from expanding neurosurgical education and health systems development to infrastructure-building initiatives, such as Duke’s pledge to construct a hospital in Uganda.

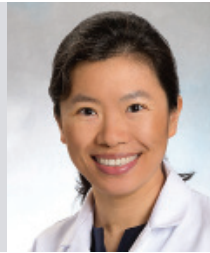
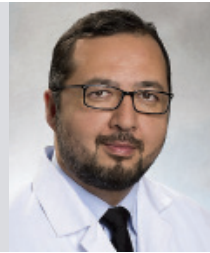
The Congress of Neurological Surgeons’ (CNS) pledge aimed to address one of the field’s persistent challenges: equitable access



Piper Tingleaf



Nirav Patel, MD, FCNS

Wenya L. Bi, MD, PhD,
FCNSMohammad Ali
Aziz-Sultan, MD, FCNS

Kee B. Park, MD

Gail Rosseau, MD,
FCNS

to high-quality education. In response, CNS submitted a pledge led by Executive Committee Member and Chair of the International Committee, Dr. Garni Barkhoudarian, committing to a comprehensive suite of low-cost and freely accessible educational resources. Recognizing that knowledge equity is foundational to building and sustaining neurosurgical capacity, CNS designed its offerings to be globally inclusive. These include virtual courses on neurosurgical emergencies and artificial intelligence, full access to CNS's flagship journals (*Neurosurgery*, *Operative Neurosurgery*, and *Neurosurgery Practice*), a curated library of videos and podcasts, and discounted memberships for LMIC professionals. These memberships provide access to CNS Nexus, clinical guidelines, webinars, mobile apps, and self-assessment tools – delivered in both synchronous and asynchronous formats to meet learners where they are and support varying levels of connectivity and infrastructure.

To ensure measurable impact, the CNS has developed a strategy for monitoring utilization and refining delivery. Educational content will be distributed in collaboration with regional partners, including the G4 Alliance, to institutions actively providing neurosurgical care in LMICs. Utilization metrics including course completion rates, geographic access data, and qualitative learner feedback will be analyzed over an initial 12-month period. These data will guide iterative improvements by the CNS Education Committee, ensuring that content remains responsive to evolving educational needs and localized contexts. By grounding its strategy in real-time engagement metrics, CNS aims to model a results-driven approach to global health resource distribution.

The momentum generated by these pledges culminated in a symbolic digital signing of the Boston Declaration, representing a unified commitment to advancing global neurosurgical care. Just days later, the Declaration was spotlighted at the 2025

AANS Annual Meeting, aligning with the meeting's theme: "The Ripple Effect: Power of One, Impact of Many." During the opening ceremony, Dr. Gail Rosseau reinforced this message in her Charles L. Plante Lecture, delivering a compelling call to action for the neurosurgical community to engage in this global movement with purpose and collaboration.

The urgency and resonance of the Boston Declaration were further amplified at the 78th World Health Assembly (WHA78) in Geneva just one month later, where the global neurosurgery delegates played a visible and vocal role. WHA78 marked the 10-year anniversaries of several foundational milestones: the release of the 2015 Lancet Commission on Global Surgery, the adoption of WHA Resolution 68.15 recognizing surgery and anesthesia as essential components of universal health coverage (UHC), and the launch of the Sustainable Development Goals (SDGs). At WHA78, neurosurgery—once viewed narrowly as a high-resource, tertiary specialty—was reframed as a strategic lever for strengthening health systems as its investments can generate a ripple effect across all critical areas of healthcare, improving imaging, perioperative services, trauma care, and intensive care capacity. Initiatives such as the Global Alliance for the Prevention of Spina Bifida and the push to designate traumatic brain injury as a notifiable condition underscored neurosurgery's expanding role in shaping national and global health policy. These developments both mirror and advance the vision of the Boston Declaration, whose five-year framework affirms neurosurgery's growing role as a catalyst for achieving the 2030 Lancet Commission global health targets.

For neurosurgeons around the world, the Boston Declaration is both a celebration of progress made and a roadmap of the work ahead. It is an open invitation to lead and collectively deliver on the promise of neurosurgical care for all. 🇺🇸

To sign the Boston Declaration or learn more about the pledges, visit: <https://forms.gle/yeXDM7ptN8wQcJWY6>

To explore CNS global programs and access educational content, visit: <https://www.cns.org>

FOUNDATION UPDATE



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Lola B. Chambless, MD, FCNS
Chair of the CNS Foundation

2026 Foundation Awards Opening November 2025

The CNS Foundation will begin accepting applications starting in November 2025. Applications will remain open through January 31, 2026. There are 13 award opportunities ranging from support for international observerships and women in leadership to community, culture and engagement efforts in innovation, impact, and health care disparities. You can find more information on our awards including the application process here-[CNS Foundation Awards](https://www.foundation.cns.org/awards).

Learn more about the CNS Foundation's impact and award opportunities at [foundation.cns.org](https://www.foundation.cns.org) and donate today:



[Foundation.cns.org](https://www.foundation.cns.org)

CNS Foundation Powers Global Access to Neurosurgical Guidelines

The CNS Foundation is the driving force behind the development and delivery of the CNS's high-quality, evidence-based clinical guidelines—essential tools for navigating today's rapidly evolving healthcare environment. Foundation support not only funds the creation, review, and renewal of these trusted guidelines, but also supports the development and content infrastructure of the CNS+ guidelines app.

Thanks to donor support, CNS Guidelines are kept current and accessible, helping neurosurgeons and their teams around the world deliver optimal, evidence-based care. No other organization produces this caliber of neurosurgical guidelines—and with continued Foundation investment, they remain within reach of those who need them most.

International Philanthropy: Building Global Neurosurgery Leaders

Through observerships and visitorships in the U.S., this initiative empowers young neurosurgeons from low- and middle-income countries to gain hands-on experience, mentorship, and global perspective. These rising stars return home not only with sharper skills—but with the tools and vision to elevate neurosurgical care in their communities. It's about growing global leadership, one future changemaker at a time.

Community, Culture, & Engagement: Reimagining a More Inclusive Future

The CNS Foundation's CCE programs are driving real change—from awarding trailblazing neurosurgeons to funding research that tackles health disparities head-on. Whether it's through innovation grants, scholarships for future women leaders, or support for equity-focused projects, this initiative is reshaping the neurosurgical field to be more inclusive, representative, and just—for both providers and patients.

Clinical Scientist Career Development: Fueling Discovery & Leadership

This initiative supports the next generation of neurosurgeon-scientists by providing over \$1.5 million in funding for research, networking, and career development. From the prestigious Getch K12 Scholar Award to Young Investigator Awards, it's designed to launch dual-clinician researchers into impactful, well-supported careers that blend patient care with scientific discovery. 

Neurosurgery Feature: Innovating with the Available Literature



Dougals Kondziolka,
MD



Danielle Golub, MD

The availability of machine learning (ML) and artificial intelligence (AI) models in medicine has rapidly increased over the past decade. ML represents the pattern recognition arm of AI that enables focused analyses of large or complex datasets to compute predictive, clinically meaningful relationships or generate data summaries. In neurosurgery, the countless task-specific ML/AI models published in the literature continue to match or outperform existing statistical models and clinical experts when addressing specific clinical questions. These models carry great potential for providing up-to-date clinical information, expediting imaging analysis, and performing literature review and data synthesis across all neurosurgical subspecialties.

Nonetheless, we have yet to see the widespread adoption or standardized use of any one ML model or AI system in neurosurgical practice or even in the literature. Task-specific models, such as those trained to detect subdural hematomas on non-contrast CT images, predict discharge disposition after traumatic brain injury, or even predict glioblastoma molecular subtypes based on both clinical and radiographic information, are inherently limited to providing solutions for their prespecified task and often can only process institutionally proprietary datasets.

These models exist in stark contrast to the publicly available generative models (such as ChatGPT) that can search all available information on the internet to generate multimodal solutions to a wide variety of queries. The persistent limitation to formally applying open-access generative AI models in medicine, however, remains the inability of these models to access peer-reviewed literature as source material, and, consequently, the tendency of these models to hallucinate sources or, more dangerously, medical facts.

Perhaps an ML/AI model of greatest utility to the neurosurgeon would be one that is not only domain-specific to neurosurgery with the ability to pull source data from peer-reviewed or other reputable sources but also is simultaneously task-agnostic—in other words, a neurosurgery domain-specific “foundation model.” Such a model would ideally represent a “middle ground” between the numerous, but narrowly focused, task-specific ML models and the publicly available, but poorly informed, open-access generative AI models.

Recently, Dr. Kondziolka’s and Dr. Oermann’s group at NYU Langone Health published preliminary findings in *Neurosurgery* on their version of such a model based on Congress of Neurological Surgeons (CNS) publications-specific data, “CNS-CLIP.”¹ CNS-CLIP is the first society-based foundational model developed with Contrastive Language-Image Pretraining (CLIP) architecture designed to address neurosurgery-specific queries. Briefly, CNS-CLIP was constructed based on data from all the PDF files available for download from the three Neurosurgery® Publications journals (*Neurosurgery*, *Operative Neurosurgery*, and *Neurosurgery Practice*) as seen in **Figure 1**. The model focused on matching figures to captions in

an attempt to train it to identify neurosurgical imaging features such that it could then correctly characterize imaging findings on novel datasets. In a direct comparison, CNS-CLIP outperformed OpenAI’s CLIP on a specifically neurosurgical information retrieval task and also demonstrated non-inferior performance on an intracranial hemorrhage classification task using a novel dataset. On a general classification task, however, OpenAI’s CLIP was found to be superior as CNS-CLIP demonstrated an expected “catastrophic forgetting” phenomenon, a tendency of more focused or fine-tuned ML models to forget past information and underperform when presented with completely novel or irrelevant datasets.

Another recently published strategy for developing a neurosurgery-specific ML/AI model suited to address multiple tasks or clinical questions involves the application of bibliometric methods to large language models (LLMs). Rather than using only society or journal-specific information as the data source, Kondziolka’s and Oermann’s group also experimented with Reference Publication Year Spectroscopy (RPYS), a bibliometric method that can identify the most influential and relevant articles on a given topic based on citation trends.² In their proof-of-concept study, the authors established the utility of an RPYS-based LLM using articles from Web of Science to answer basic clinical questions regarding surgical management, pathophysiology, and natural history in four common spinal pathologies: cervical myelopathy, lumbar radiculopathy, lumbar stenosis, and adjacent segment disease (**Figure 2**). The LLM based on the RPYS literature-oriented prompting scheme was able to consistently generate query response summaries with accurately cited statistics and statements, while the

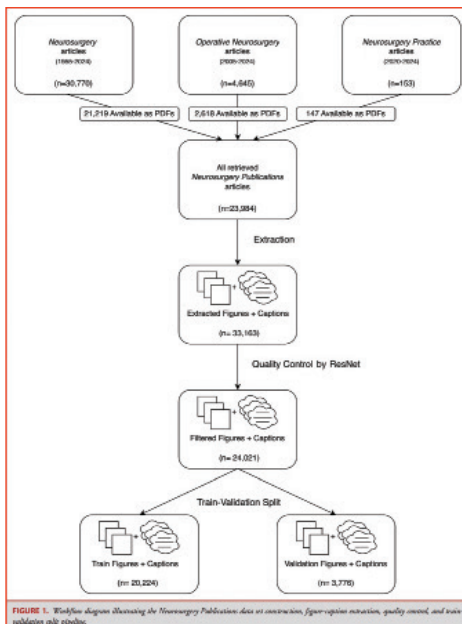


FIGURE 1. Workflow diagram showing the Neurosurgery Publications data extraction, figure-caption extraction, quality control, and train-validation split pipeline.

Figure 1. Adapted from Alyakin et al, 2025, Wolters Kluwer. Used with permission.

native LLMs intermittently either refused to provide citations or generated false sources or statistics. Board-certified neurosurgical spine faculty were additionally surveyed to assess response quality and agreed that the RPYS-trained LLM provided more focused,

detailed, and well-supported answers.

Accessibility and broad implementation of these neurosurgery-specific ML/AI models nevertheless remains an ongoing issue. In response, over the last few years, Neurosurgery Publications has published a series of “with code” articles highlighting task-specific ML models that are accompanied by direct links to the associated ML model code so that readers can potentially run the models themselves with their own data. For example, code for peer-reviewed ML models to predict functional outcomes after a traumatic subdural hematoma³, to assess disease severity in degenerative cervical myelopathy⁴, or even to perform a bibliometric analysis of literature in pediatric spine surgery⁵, is readily available for download from the Neurosurgery Publications website. It is conceivable that over the next several years, this enhanced accessibility of ML code across neurosurgery (and the potential for several unique datasets to be run through the models) will generate more accurate, refined, and generalizable ML tools that are more readily integrable into clinical practice.

Specialty-specific ML and AI models hold great promise for shaping the future of neurosurgical research and practice, but

their success will depend on both thoughtful design, accessibility, and rigorous safeguards against fabricated content. By grounding such models in peer-reviewed sources (or even more narrowly to society-specific literature) or leveraging bibliometric approaches to highlight the most influential studies, these tools can align more closely with the evidence-based standards central to neurosurgery. While each strategy has its limitations, these “middle ground” neurosurgical foundational models represent some of the first domain-specific alternatives to large, open-access generative AI models for medical queries, and, furthermore, provide a framework for researchers from other medical subspecialties to follow suit. Additionally, data sharing and, more recently, code sharing remain critical for the continued implementation, growth, and refinement of these increasingly valuable ML/AI tools in neurosurgery. ■

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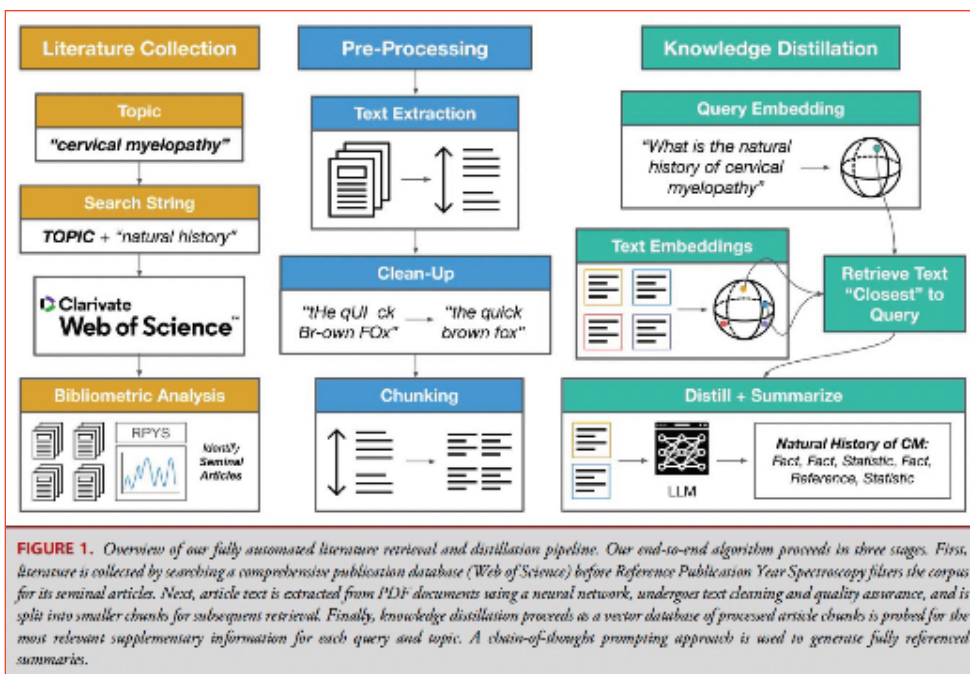


FIGURE 1. Overview of our fully automated literature retrieval and distillation pipeline. Our end-to-end algorithm proceeds in three stages. First, literature is collected by searching a comprehensive publication database (Web of Science) before Reference Publication Year Spectroscopy filters the corpus for its seminal articles. Next, article text is extracted from PDF documents using a neural network, undergoes text cleaning and quality assurance, and is split into smaller chunks for subsequent retrieval. Finally, knowledge distillation proceeds as a vector database of processed article chunks is probed for the most relevant supplementary information for each query and topic. A chain-of-thought prompting approach is used to generate fully referenced summaries.

Figure 2. Adapted from Kurland et al, 2025, Wolters Kluwer, Used with Permission.

INSIDE THE CNS



Washington Committee Update



Alexander Khalessi
MD, MBA, FACS, FCNS
Chair, Washington
Committee



Charlotte Pineda, MPP
Vice President, Health
Policy and Advocacy

Prior Authorization Takes Center Stage

The Washington Committee continues to lead efforts to reform prior authorization (PA), with momentum accelerating on multiple fronts.

At the center of growing concern is the Centers for Medicare & Medicaid Innovation's (CMMI) proposed [Wasteful and Inappropriate Services Reduction \(WiSeR\) Model](#). Beginning January 2026, this six-year mandatory demonstration will use third-party vendors to review claims for selected "low-value" [services](#), including epidural steroid injections for pain management, electrical nerve stimulator implants, percutaneous vertebral augmentation for vertebral compression fracture, cervical fusions, and percutaneous image-guided lumbar decompression for lumbar spinal stenosis. The model will apply to traditional Medicare patients in six states (NJ, OH, OK, TX, AZ, WA) and marks a sharp policy turn that could reintroduce the very access and administrative issues recently addressed in Medicare Advantage reforms.

The Washington Committee responded through several of its coalitions. The Regulatory Relief Coalition (RRC), of which the AANS and CNS are founding members, [submitted formal comments](#) opposing the WiSeR model. The Washington Committee also joined the Surgical Coalition in a [parallel letter](#) opposing the model, citing concerns about reduced patient access, increased administrative burden on physicians, and perverse payment incentives for third-party vendors.

The Washington Committee took those letters to the Hill in a grassroots advocacy campaign led by Chair **Alexander Khalessi**, MD, MBA, FCNS, where leading neurosurgeons met directly with congressional champions in the Senate and House. These conversations prompted CMMI to offer a meeting with Washington Committee staff and its allies to come to the table and offer solutions to improve the demo.

Physician and patient backlash on WiSeR has drawn bipartisan scrutiny on Capitol Hill. On July 22, the House Ways and Means Committee held a hearing, [Medicare Advantage: Past Lessons, Present Insights, Future Opportunities](#), where many Representatives discussed insurer abuse in PA. Representative **Suzan DelBene** (D-WA) focused her line of questioning on WiSeR to highlight the perverse payment incentives and administrative burdens it would place on already stretched practices. Rep. DelBene followed her remarks with serious questions in a [sign-on letter](#) alongside Representative **Ami Bera**, MD (D-CA), and 15 other Representatives. The letter requests that CMS respond by September 1.

[Newsweek](#), [MedPage Today](#), [The Hill](#), [MarketWatch](#), and other news outlets have spotlighted the backlash, amplifying concerns raised by Members of Congress and the physician community.

In preparation for the hearing, the Washington Committee met with Committee members and [submitted formal testimony for the record](#). It called for final passage

of the Improving Seniors' Timely Access to Care Act ([S. 1816/H.R. 3514](#)). Support for the legislation continues to grow with 169 House and 54 Senate cosponsors.

Washington Committee Members Lobby Congress and HHS

On July 10, the Washington Committee held a targeted fly-in to advocate for neurosurgery's top legislative and regulatory priorities. Neurosurgeons conducted 20 meetings across the House and Senate, engaging directly with key lawmakers and staff on physician payment reform, prior authorization, Medicaid proposals in the One Big Beautiful Bill Act, the WiSeR model, and graduate medical education.

Neurosurgeons met directly with Senators **Roger Marshall**, MD (R-KS), and U.S. Representatives **Kim Schrier**, MD (D-WA), **Neal Dunn**, MD (R-FL), **Suzan DelBene** (D-WA), and **Herb Conaway**, MD (D-NJ). They also met with senior staff with Senators **Elizabeth Warren** (D-MA), **Chuck Schumer** (D-NY), **Ed Markey** (D-MA), **Alex Padilla** (D-CA), and **Chuck Grassley** (R-IA), and Representatives **John Joyce**, MD (R-PA), **Danny Davis** (D-IL), **Katherine Clark** (D-MA), **Yasmin Ansari** (D-AZ), **August Pfluger** (R-TX), and **David Schweikert** (R-AZ).

The following day, Dr. Khalessi welcomed two senior federal officials for a forward-looking policy dialogue on digital health. **Thomas Keane**, MD, Director of the Advanced Standards and Technology Partnerships Division at the Office of the National Coordinator for Health Information Technology, discussed interoperability, artificial intelligence, and the Trusted Exchange Framework and Common Agreement (TEFCA). He emphasized ASTP/ONC's commitment to keeping physicians central to digital health innovation while acknowledging persistent challenges related to EHR usability and information blocking.

Kenneth Callahan, Chief Policy Officer at the U.S. Department of Health and Human

Services, outlined the Administration's regulatory streamlining agenda, including implementation of the Unleashing Prosperity Through Deregulation Executive Order. He also highlighted opportunities for specialty societies to inform Medicare administrative simplification efforts. Committee members raised concerns regarding real-world data integration, burdensome quality reporting requirements, and the need for meaningful reforms to prior authorization.

Neurosurgery Urges Congress to Close Gaps in Digital Health Policy

On July 9, the Washington Committee submitted a [statement for the record](#) in response to the House Ways and Means Subcommittee hearing, [Harnessing the Power of Digital Health](#).

The statement emphasized the promise of digital health data to improve patient outcomes, efficiency, and research, while highlighting ongoing challenges related to interoperability, standardized patient matching, meaningful access to federal claims data, and quality reporting under the Merit-Based Incentive Payment System.

The Washington Committee urged Congress to advance policies that enable seamless data sharing, support the role of registries, and foster responsible innovation to improve patient care. The letter also highlighted the value of telehealth in neurosurgical care. It urged flexible, safety-focused regulation of emerging digital technologies, such as artificial intelligence, that recognize the unique needs of each patient.

Alliance for Specialty Medicine Endorses GME Bill

On August 6, the AANS and CNS joined the Alliance of Specialty Medicine in supporting the Resident Physician Shortage Reduction Act of 2025 ([S.2439/H.R.4731](#)). The legislation would increase the number of Medicare-supported GME positions by an additional 2,000 residency positions each year for seven years.

The letter emphasized that specialty shortages are particularly acute in surgical and non-primary care fields and are especially pronounced in rural and

underserved areas. It urged lawmakers to consider targeted distribution strategies that ensure the new slots expand access to needed specialty services.

Access to Claims Data Act Reintroduced

On August 4, the Neurosurgery Quality Council, chaired by **John Knightly**, MD, led efforts to join the Registry Coalition in [thanking](#) Representatives **John Joyce**, MD (R-PA), and **Kim Schrier**, MD (D-WA) for their leadership in reintroducing the bipartisan Access to Claims Data Act ([H.R. 4331](#)).

Under the Medicare Access and CHIP Reauthorization Act (MACRA), CMS is required to provide Medicare claims data to registries "for purposes of linking such data with clinical outcomes data and performing risk-adjusted, scientifically valid analyses and research to support quality improvement or patient safety."

The Access to Claims Data Act seeks to address significant ongoing regulatory barriers that have prevented meaningful access to this data by requiring CMS to establish a process to allow clinician-led clinical data registries to request and obtain timely, broad, and continuous access to federal claims data for research, quality of care measurement, and reporting.

CMS Releases 2024 Open Payments Data

On June 30, CMS published Open Payments Program Year 2024 data, along with newly submitted and updated payment records for Program Years 2018 – 2023. The data is accessible on the [Open Payments Search Tool](#).

Open Payments, a national disclosure program, publishes information on payments from pharmaceutical and medical device companies to physicians, non-physician practitioners, and teaching hospitals.

The Open Payments data will be refreshed in 2026 to reflect any updates made to the data between now and December 31. The Drugs and Devices Committee, chaired by **Joshua Rosenow**, MD, FCNS, encourages neurosurgeons to routinely review their records and address discrepancies during the annual review and dispute period (April 1–May 15).

MEDCAC Reviews Clinical Endpoints for Parkinson's and Essential Tremor

On June 25, the Medicare Evidence Development and Coverage Advisory Committee (MEDCAC) convened to examine what clinical endpoints should be of interest to CMS in studies of devices for the management of tremor in patients with Parkinson's Disease or essential tremor. CMS selected this topic due to its relevance to the Medicare population and the broad range of potential endpoints.

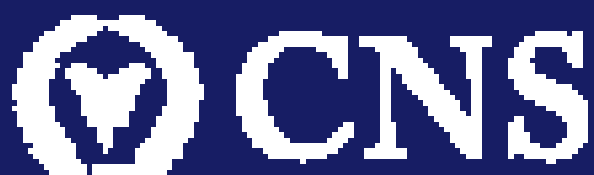
Representing neurosurgery, **Joshua Rosenow**, MD, FCNS, presented evidence supporting the use of deep brain stimulation (DBS), outlined optimal clinical endpoints for DBS in Parkinson's and essential tremor, emphasizing motor function, quality of life, cognition, and safety. "Most active DBS centers are doing both presurgical and 12-month postsurgical testing," noted Dr. Rosenow, highlighting the importance of consistent cognitive assessments in evaluating patient outcomes. He cautioned against using balance, speech, or swallowing as primary endpoints, stating these are unlikely to improve postoperatively and are often confounded by disease progression.

Dr. Rosenow also responded to questions on device tolerability, explaining that chronic discomfort is rare and modern implants are smaller and more tolerable. He concluded that outcome measures should reflect realistic surgical benefits.

More information, including Dr. Rosenow's presentation and meeting materials, is available [here](#).

JGRC Endorses New Pituitary Adenoma Guideline

The Joint Guidelines Review Committee, chaired by **Jennifer Sweet**, MD, FCNS, endorsed a new CNS evidence-based Guideline on the [treatment of functioning pituitary adenomas in adults](#). This marks the first guideline on the topic jointly considered by AANS and CNS, with evidence-based recommendations on endocrine management, imaging, surgery, and radiation. ◀



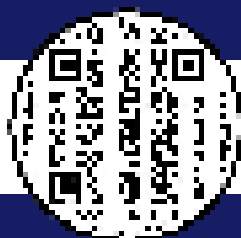
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IMAGES IN NEUROSURGERY

Giant Right Frontal Convexity Meningioma

We present a 46-year-old female who presented with a generalized tonic-clonic seizure. Patient recovered from post-ictal state within 24 hours after ICU admission and initiation of levetiracetam. MRI of the brain with and without contrast demonstrated a giant right frontal convexity meningioma (~7cm) with vasogenic edema (**Figure 1**). Given the large size of the meningioma, a preoperative angiogram and tumor embolization was performed with Onyx 18 through Scepter Mini balloon microcatheter (**Figure 2 and 3**). A right frontal craniotomy was performed the day after embolization and gross total resection of the giant right frontal convexity meningioma was achieved (**Figure 4**). The operative time was less than three hours and the blood loss was less than 200cc. The patient did not require any blood transfusions and was discharged to home on postoperative day four. At last clinic follow-up, patient has remained seizure free and has returned to work. ■

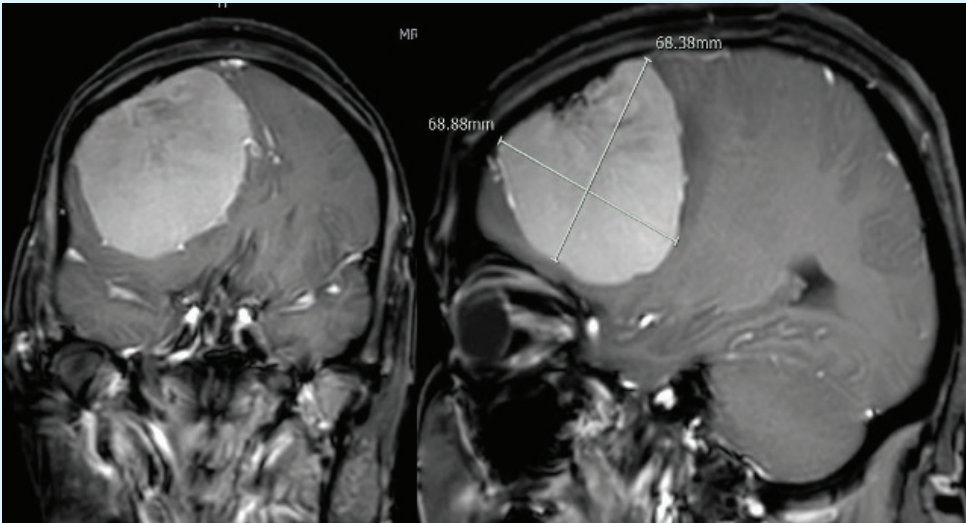


Figure 1: MRI of the brain with and without contrast coronal and sagittal views demonstrating giant right frontal meningioma (~7cm)

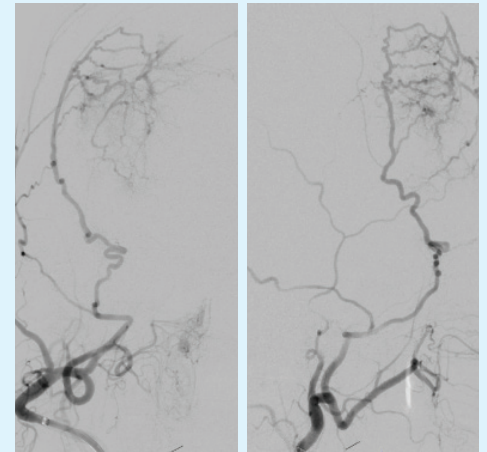


Figure 2: Preoperative right external carotid artery AP and lateral projections demonstrating significant tumor blush from the right middle meningeal artery

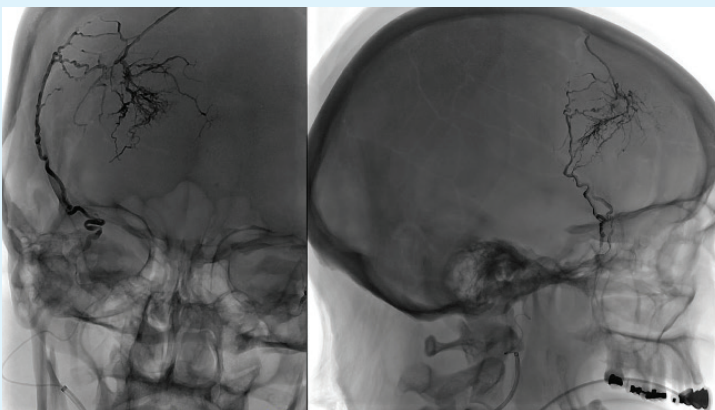


Figure 3: Single fluoroscopy shot AP and lateral views showing penetration of Onyx 18 embolisate in the microvasculature of the meningioma

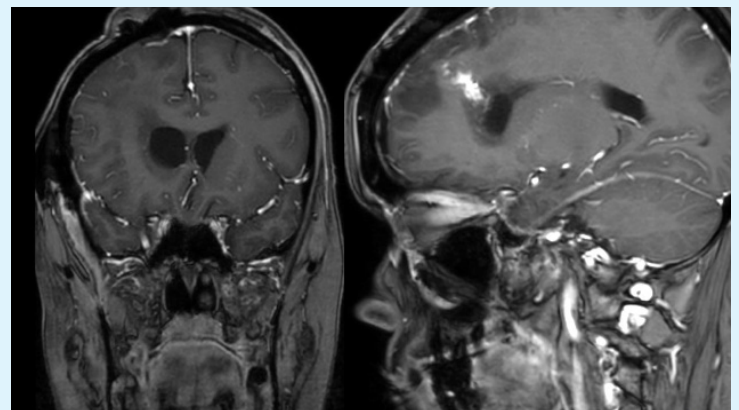


Figure 4: Postoperative MRI of the brain with and without contrast coronal and sagittal views demonstrating gross total resection of meningioma



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