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Innovations in Robotics and Navigation, Part 2

PAUL C. MCAFEE, MD, MBA[1]; ISADOR H. LIEBERMAN, MD, MBA[2]; AND NICHOLAS THEODORE, MD[3]
[1]*Georgetown University School of Medicine, MedStar Union Memorial Spine Center, Baltimore, MD, USA;* [2]*Texas Back Institute, Plano, TX, USA;* [3]*Department of Neurosurgery, Johns Hopkins University, Baltimore, MD, USA*

About 1 year ago, we solicited manuscripts on spinal navigation and robotics for an *International Journal of Spinal Surgery* special issue. The response was so successful that we had enough high-quality manuscripts on innovative topics to divide this timely subject into a 2-part series. When considering the innovations in personal computing, initially the focus was on more computing power with Moore's law. However, once a critical computing power threshold was reached, consumers wanted more portability, more battery life, head-mounted computers, augmented reality, and other differentiating characteristics. As this Part 2 special issue attests, the focus on navigation and robotics is not just about improving anatomic accuracy—now there are several techniques and technologies designed to increase the speed of intraoperative registration, reduce line-of-sight issues, reduce radiation exposure, use augmented reality, and increase portability (smaller and lighter hand-held robots). This is a sign that the technology is sustainable and closer to being included in a "standard of care" (SOC) discussion.

With the adoption of innovative technology that increases safety and gains momentum, there is always a time in the adoption curve when surgeons wonder if the procedure or approach has become the SOC—spinal cord monitoring, cervical disc replacement, pedicle screw instrumentation, and so on. Satin et al review the available evidence for whether robotic spine surgery will eventually become the SOC for spine surgery. Of note, SOC has both a legal and a clinical definition. Legal SOC is defined as the level of care that a reasonably competent and skilled health care professional, with a similar background and in the same medical community, would have provided under the circumstances that led to an alleged breach of care. The legal community has established 4 pillars in their effort to define the SOC—knowledge, skill, diligence, and care. However, SOC continues to evolve with time. It is an interesting discussion and perspective with regard to whether navigation and robotics will fit their criteria and become the SOC. We leave this open to the interpretation of the reader.

Stewart presents a compelling single-surgeon series of 150 consecutive cases using the 7D system of visible light navigation in place of intraoperative computed tomography or fluoroscopic imaging. Because the registration utilizes flashes of light behind a proprietary grid, the intraoperative registration and cost are lower than most other systems, and the intraoperative workflow is improved, as it is with the innovative system introduced by Foley et al. Instead of a skeletally based dynamic reference base anchored into the pelvis like the Excelsius and Mazor systems, Foley et al anchor a visible light camera to the operating room table. It utilizes a fish-eye lens that allow direct line of sight with the operative field.

In terms of applications, the greatest advance has been the addition of robotics and navigation to include percutaneous cervical spine pedicle screw instrumentation. This was originally thought of as such a demanding technique that it was only promoted on a large scale by Abumi in Japan—but as the experience of Lieberman et al and Coric and Rossi attests—the advancements of robotics and navigation have increased the safety of using cervical pedicle screws from C3 to C6 and allow utilization of large screws for optimal fit. Even Abumi et al, with thousands of case experience, could not advocate percutaneous cervical spine pedicle screw insertion.

The article by Qureshi et al focuses on minimally invasive spine surgery and robotics—the true test of success is performing this surgery in an outpatient surgicenter. The cost-effectiveness is critical in self-sustaining surgicenters, so if an ambulatory surgical center can increase efficiency, then certainly a traditional medical center can as well. There has been a gradual increase in transitioning total hip and total knee replacement from medical centers into ambulatory surgical centers, and minimally invasive surgery robotics for the spine can serve as a catalyst accelerating this role for spinal reconstructive surgery.

Qureshi et al believe a great advantage for navigation and robotics is the single position lateral interbody cage and posterior fixation, which they argue is not possible without robotics and has the advantage of the ability to place pedicle screws accurately in an oblique position. They feel this is challenging when done freehand due to unfamiliar angles, and the robot adds “real value,” particularly when placing the downside pedicle screws.

Finally, Satin et al present an interesting set of 3 difficult revision cases that illustrate the workflow and advantage of spinal robotics and navigation in cases: (1) planning osteotomies and redrilling misplaced pedicle screw trajectories, (2) placing pedicle screws into a prior fusion mass with altered landmarks, and (3) navigation and robotically placed pedicle screws in the cervical spine. Ultimately, a convincing argument is made that the advantages of the robotic platform extend well beyond the placement of pedicle screws because it provides improved preoperative planning, intraoperative registration, and, more accurately, predicts optimal global deformity correction.

As we stated in our introduction to Part 1 of the Navigation and Robotics issue, we hope these 2 special issues provide you with clinically relevant insights into the use of robotics and navigation in spine surgery.

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Corresponding Author: Paul C. McAfee, Georgetown University School of Medicine, MedStar Union Memorial Spine Center, 3333 N Calvert St Suite 655, Baltimore, MD 21218, USA; mack8132@gmail.com

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