Neurospine 2023;20(3):1088-1090.
https://doi.org/10.14245/ns.2346814.407

Neurospine
pISSN 2586-6583 eISSN 2586-6591

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Commentary

Advancing the Adoption of Robot-Assisted Surgery as the Routine Minimally Invasive Approach in Spinal Procedures: Commentary on "Floor-Mounted Robotic Pedicle Screw Placement in Lumbar Spine Surgery: An Analysis of 1,050 Screws"

Lu-Ping Zhou[1,2], Ren-Jie Zhang[1,2], Cai-Liang Shen[1,2]

[1]Department of Orthopedics and Spine Surgery, the First Affiliated Hospital of Anhui Medical University, Hefei, China
[2]Laboratory of Spinal and Spinal Cord Injury Regeneration and Repair, the First Affiliated Hospital of Anhui Medical University, Hefei, China

Corresponding Author
Cai-Liang Shen
https://orcid.org/0000-0002-9835-6384

Department of Orthopedics and Spine Surgery, the First Affiliated Hospital of Anhui Medical University, 218 Jixi Road, Hefei, Anhui 230022, China
Email: shencailiang@ahmu.edu.cn

See the article "Floor-Mounted Robotic Pedicle Screw Placement in Lumbar Spine Surgery: An Analysis of 1,050 Screws" via https://doi.org/10.14245/ns.2346070.035.

The development of artificial intelligence and communications technology has revolutionized field of healthcare, particularly in the realm of spinal procedures. One notable advancement in this area is the utilization of robot-assisted (RA) techniques in spinal surgery, which provide enhanced safety, accuracy, and minimal invasion compared to conventional surgical techniques.[1]

Shahi et al.[2] investigated the application of floor-mounted robot (ExcelsiusGPS, Globus Medical, Inc., Audubon, PA, USA) in minimally invasive lumbar fusion. They included a large sample size of 229 patients with 1,050 pedicle screws, and found that the accuracy of pedicle screw placement in RA methods was 96.4%, and the proximal facet and proximal endplate violation rates were 0.4% and 0.9%, respectively, indicating that RA techniques contributed to excellent accuracy, large screw size, and negligible screw-related complications.

However, RA systems are currently in its early stages, mainly used for the pedicle and translaminar screw instrumentation, and the conventional percutaneous and open freehand techniques still dominate in clinical practice. Consequently, significant progress remains for RA spinal surgery to become a routine minimally invasive approach in spinal procedures, which is an inevitable trend in the field.

To facilitate the routine implementation of RA techniques in minimally invasive surgeries, we proposed the following methodologies.

First, the most fundamental approach is to promote the innovation and upgrade of robot systems to satisfy the diverse requirements: (1) Achieving safe screw placement throughout the entire spinal segments. RA techniques have been widely investigated in thoracolumbar spine surgery, the feasibility and safety of which have been confirmed in many randomized controlled trials, demonstrating promising clinical and radiographic results.[3] However, the implementation of RA techniques in cervical spinal surgery is still limited due to the complexed cervical anatomy and vulnerability to catastrophic complications from malposition.[4] Although the RA cervical screw placement has been determined to be safe and feasible in our previous study, with optimal and clinically acceptable accuracies of 88.0% and 98.4% respectively, it is essential to improve precision and accuracy, as well as enhance real-time visualization and tracking systems.[5] These enhancements are necessary to addressing surgeons' reluctance when considering RA cervical spinal surgery, and to foster their confidence during surgical procedures. Overcoming the challenges presented by RA cervical spinal surgery is a crucial aspect for the successful integration of RA techniques into routine practice. (2) Achieving safe screw placement for different types of screws and screw placement techniques. On the one hand, it is necessary to integrate RA techniques with the currently available screw types and surgery procedures. Recently, RA techniques have been applied in the midline lumbar interbody fusion using cortical bone trajectory screw, oblique lumbar interbody fusion, and percutaneous kyphoplasty.[6-8] On the other hand, there are only several percutaneous cervical screw systems available. Presently, posterior C1–2 screw insertions are frequently conducted,[9] but there is a need to develop innovative percutaneous cervical screw systems specifically tailored for RA procedures. (3) Achieving safe screw placement in various malformed and degenerative vertebral bodies. The robot systems can preplan the optimal entry point and trajectory for accurate screw placement based on the 3-dimensional images displaying the abnormal and degenerative structures. The systems require further upgrading in order to ensure safe operations for severe malformed and degenerative diseases, including basilar invagination, kyphosis deformity resulting from ankylosing spondylitis, and severe fractures. (4) Achieving safe screw placement during remote interactions and improving related policies and regulations. Utilizing robotic technology and mutual telecommunication networks, medical information, including images, audio, and video, can be digitally transmitted over long distances to facilitate real-time remote surgery.[10] The fifth generation mobile communication technology, commonly referred to as 5G, enables high-speed, low-latency, and high-capacity wireless communication, extensive connectivity, and seamless integration of industrial networks, thereby facilitating remote RA cervical spinal surgery.[11] However, there is a lack of detailed rules for determining liability in cases of Internet medical accidents, and the ownership of medical data on cloud storage has not been clearly determined under the curry legislation.[12] Thus, the legal supervision systems for the Internet medical service industry need further improvement, and the standards for 5G remote surgery and specific requirements with details are urgently needed.

Second, the RA training of surgeons is crucial for the promotion of orthopedic surgical robots. Pennington et al.[13] found evidence of a learning curve in spinal robotics, with the typical minimum experience threshold ranging from 20 to 30 cases. The effective training empowers surgeons to enhance technical skills, develop surgical strategies, and master management of safety and risk during the use of orthopedic robots. This ensures standardized surgical procedures and promotes teamwork, thereby enhancing the quality and safety of RA surgery.

Third, economic and policy support plays a crucial role in promoting the widespread adoption of RA surgery.[14] It is imperative to increase investment in technological innovation and upgrades of robotics to reduce the costs associated with purchasing and maintaining these robots. Meanwhile, reforms to healthcare insurance institutions and government policies are necessary, which should include the addition of RA surgery to the scope of reimbursement, as well as the supervision of Internet medical services.

Fourth, it is crucial to raise patient awareness and acceptance of RA surgery. Patients can be educated about the advantages and potential benefits of robotic surgery, including minimized invasiveness, surgical precision, and accelerated recovery. Moreover, it is possible to establish a communication channel with patients, to answer their questions and explain the RA surgical process.

Finally, the organization of large-scale data, conduction of rigorous clinical research, and systematic accumulation of evidence on RA surgery is essential. These data will provide strong support for the widespread application of RA surgery and help us further upgrade RA systems and improve surgical techniques.

The routine implementation of RA techniques as the minimally invasive approach in spinal procedures is an inevitable trend in the future. With the incorporation of artificial intelligence and communications technology, spinal robots have the potential to serve as either main or independent surgical operators. As Dr. Theodore, the inventor of the ExcelsiusGPS robot, pointed out, the future of robotics is bright.[15]

• **Conflict of Interest:** The authors have nothing to disclose.

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