Neurospine 2023;20(1):340-342.
https://doi.org/10.14245/ns.2346312.156

Neurospine
pISSN 2586-6583 eISSN 2586-6591

Commentary

Commentary on "Robotics in Cervical Spine Surgery: Feasibility and Safety of Posterior Screw Placement"

Gianluca Vadalà[1], Luca Ambrosio[2], Vincenzo Denaro[1]

[1]Operative Unit of Orthopaedic and Trauma Surgery, Fondazione Policlinico Universitario Campus Bio-Medico, Rome, Italy
[2]Research Unit of Orthopaedic and Trauma Surgery, Department of Medicine and Surgery, Università Campus Bio-Medico di Roma, Rome, Italy

Corresponding Author
Gianluca Vadalà
https://orcid.org/0000-0001-7142-1660

Research Unit of Orthopaedic and Trauma Surgery, Department of Medicine and Surgery, Università Campus Bio-Medico di Roma, Via Alvaro del Portillo, 200 – 00128, Rome, Italy
Email: g.vadala@unicampus.it

See the article "Robotics in Cervical Spine Surgery: Feasibility and Safety of Posterior Screw Placement" via https://doi.org/10.14245/ns.2244952.476.

Over the last few decades, emerging technologies and high-end equipment have rendered minimally invasive spine surgery (MISS) the standard of care for several different spinal procedures. Compared to traditional open surgery, MISS has demonstrated to significantly reduce blood loss, hospital stay, surgical site infection, and postoperative narcotic requirements.[1] In this regard, the use of spinal navigation technologies for percutaneous pedicle screw and interbody cage placement has allowed a more efficient workflow and improved safety in MISS procedures.[2,3] Moreover, robotic-assisted (RA) systems have been introduced as competitive or complementary tools to the use of spinal navigation.[4,5] To date, safety and efficacy of navigated thoracolumbar instrumentation has been extensively demonstrated. Indeed, increased accuracy with navigated screw placement has been associated with promising clinical and radiographic outcomes. Therefore, the advantages and feasibility of spinal navigation in thoracolumbar spine surgery are well established.[4]

However, the application of RA techniques in cervical spine surgery has been delayed due to the unique anatomical and biomechanical characteristics of the cervical spine. During surgery, the cervical segment is substantially more mobile compared to the thoracolumbar spine, especially when applying pressure on bony structures. Unwanted movements can lead to screw misplacement due to deviation from preplanned entry point and trajectory of RA instruments, with possibly devastating neurovascular complications. In addition, the cervical spine is characterized by a considerable anatomic variability, especially in case of severe trauma, advanced degeneration, and developmental abnormalities.[6] These aspects must be carefully taken into account by the surgeon experienced in thoracic and lumbar RA MISS techniques when operating on the cervical spine.

In this paper,[7] the authors have performed a single-arm meta-analysis to evaluate feasibility, safety and accuracy of cervical screw placement using RA tools. More specifically, the authors have systematically reviewed all available studies in which cervical spine instrumentation was performed with RA methods and screw accuracy was reported as the primary outcome. Secondary outcomes included mean blood loss and average operation time. Unsurprisingly, the quality of extracted evidence was limited by the moderate risk of bias of the only randomized controlled trial included, while remaining manuscripts were composed of small cohort studies or noncontrolled case series. Moreover, most included papers reported the use of TiRobot (Tinavi Medical Technologies, Beijing, China), which is not li-

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (https://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Copyright © 2023 by the Korean Spinal Neurosurgery Society

censed for use outside China, thus further limiting the generalizability of results. Overall, the authors reported that 97.8% of the screws were clinically acceptable, namely fully intrapedicular without breach of the pedicle cortex or with a cortical breaching <2 mm, corresponding to Gertzbein and Robbins grades A and B, respectively.[8] Interestingly, the rate of Gertzbein and Robbins grade A screws reached 96.2% in instrumented C1 vertebrae, while dropping to 89.7% in C2 and 82.6% in subaxial vertebrae. This can be imputed by the considerable variability of pedicle width in the subaxial cervical spine, which may have hampered optimal screw placement.[9] However, the percentage of clinically acceptable screws was still higher than 95% in all subgroups.

Furthermore, the authors have reported that RA cervical spine instrumentation resulted in a mean blood loss of 197.67 mL and an average operative time of 268.88 minutes. While reduced blood loss is advantageously correlated with decreased surgical invasiveness and lesser anatomical exposure, longer operation time is a significant drawback of contemporary computer-assisted navigation (CAN) and RA tools in spine surgery. This may result from a combination of several factors, including increased setup time, steep learning curve, need for intraoperative recalibration and readjustment, additional staff requirements, and technical issues. Nonetheless, the use of spinal navigation and RA technologies has been associated with reduced intraoperative radiation exposure, lower surgical site infection rates, and diminished hospital stay.[10] Although promising, the data presented in this study should be cautiously interpreted. Due to the paucity of controlled trials, the lack of a comparative meta-analysis does not allow to draw scientifically sound conclusions on safety and efficacy of RA screw placement in cervical spine surgery. Indeed, additional studies directly comparing RA techniques with conventional free-hand or CAN approaches are required to confirm feasibility and superiority of the former. This also poses relevant ethical issues, as allocating patients to a less advanced technology, although established for decades as the standard of care, might not be acceptable in all clinical contexts. Furthermore, as adverse events occurring in included studies have not been analyzed and discussed, attention must be paid to the definition of surgical safety.

While still in its infancy, RA cervical spine surgery appears a promising field which may potentially revolutionize the surgical treatment of increasingly common conditions. Though technological advancements offer new tools at a relentless pace, there is an urgent need in the spine community to gather high-quality data that may corroborate safety, efficacy, and cost-effectiveness of MISS approaches. Indeed, most clinical studies investigating the applicability of novel technologies in spine surgery are usually poorly designed, noncontrolled and without enough statistical power to detect clinically meaningful differences. As a result, despite intriguing innovations, most quantitative analyses and evidence summaries conclude that there is no recommendation in favor or against the majority of discussed points.[11] We are optimistic that high-quality research in the next future will definitely shed a bright light on the immense potential of RA technology in spine surgery.

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

REFERENCES

1. Goldberg JL, Härtl R, Elowitz E. Minimally invasive spine surgery: an overview. World Neurosurg 2022;163:214-27.
2. Schmidt FA, Lekuya HM, Kirnaz S, et al. Novel MIS 3D NAV single step pedicle screw system (SSPSS): workflow, accuracy and initial clinical experience. Global Spine J 2021;12:1098-108.
3. Kirnaz S, Gebhard H, Wong T, et al. Intraoperative image guidance for cervical spine surgery. Ann Transl Med 2021; 9:93.
4. Staartjes VE, Klukowska AM, Schröder ML. Pedicle screw revision in robot-guided, navigated, and freehand thoracolumbar instrumentation: a systematic review and meta-analysis. World Neurosurg 2018;116:433-43.e8.
5. Han X, Tian W, Liu Y, et al. Safety and accuracy of robot-assisted versus fluoroscopy-assisted pedicle screw insertion in thoracolumbar spinal surgery: a prospective randomized controlled trial. J Neurosurg Spine 2019 Feb 8:1-8. doi: 10.3171/2018.10.SPINE18487. [Epub].
6. Wallace N, Schaffer NE, Freedman BA, et al. Computer-assisted navigation in complex cervical spine surgery: tips and tricks. J Spine Surg 2020;6:136-44.
7. Zhou LP, Zhang ZG, Li D, et al. Robotics in cervical spine surgery: feasibility and safety of posterior screw placement. Neurospine 2023;20;329-39.
8. Gertzbein SD, Robbins SE. Accuracy of pedicular screw placement in vivo. Spine 1990;15:11-4.
9. Mao JZ, Soliman MAR, Karamian BA, et al. Anatomical and technical considerations of robot-assisted cervical pedicle screw placement: a cadaveric study. Global Spine J 2022 Feb 23:21925682211068410. doi: 10.1177/21925682211068410. [Epub].

10. Vadala G, De Salvatore S, Ambrosio L, et al. Robotic spine surgery and augmented reality systems: a state of the art. Neurospine 2020;17:88-100.
11. Jiang F, Wilson JRF, Badhiwala JH, et al. Quality and safety improvement in spine surgery. Global Spine J 2020;10(1 Suppl):17S-28S.

https://doi.org/10.14245/ns.2346312.156