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Robotic-Assisted Spinal Surgery
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Questions or requests for information about this report can be directed to Requests@CADTH.ca.
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Key Messages

- The use of robotic systems to aid in surgical procedures, including spinal surgeries, has been on the rise over the past several years.
- Systematic reviews and economic evaluations on the clinical and cost-effectiveness of robotic-assisted surgical systems used for patients requiring spinal surgeries that do not involve pedicle screw placement are lacking.

Context and Policy Issues

Spinal fusion procedures for conditions such as disc herniation, spondylolisthesis, and spinal stenosis have been traditionally performed by securing a bone graft that promotes fusion between vertebrae with metal pedicle screws, which are inserted using free-hand methods. Free-hand surgeries are associated with potential complications, as improper screw placement can lead to damage to the blood vessels and nerve roots close to the insertion sites, resulting in potential vascular, neurological, and visceral damage. Injuries and complications can include leakage of cerebrospinal fluid, blood loss, and deep wound infection. Approximately 30,000 adults living in Canada undergo spine surgery annually, thereby creating a demand for technological advances within the field to improve patient outcomes, reduce the risk of intraoperative and postoperative complications, and decrease the need for revision surgeries.

Robotic assistance in spinal surgery was initially developed as a way to improve the accuracy of pedicle screw placement in fusion procedures and to reduce the risk of manual fixation, with the first robot approved by the FDA for this indication being the SpineAssist by Mazor Robotics in 2004. Mazor X, the latest robotic-guided system for spinal surgery approved for use in Canada, is marketed primarily for preoperative or intraoperative planning of procedures that involve screw placement. Compared to previous systems, the Mazor X has a more advanced camera system for intraoperative navigation as well as an improved robotic arm that allows for greater mobility. While there is considerable literature investigating the comparative clinical effectiveness of robotic-assisted spinal surgery systems versus conventional methods in the realm of pedicle screw placement, it is unclear whether robotic systems are beneficial for other types of complex spinal operations, such as tumour resections or laminectomy (i.e., partial or full removal of the vertebral bone).

The objective of this report is to summarize the evidence regarding the clinical and cost-effectiveness of robotic-assisted surgical systems used for patients requiring spinal surgery procedures that do not involve pedicle screw placement.

Research Questions

1. What is the clinical effectiveness of robotic-assisted surgical systems used for patients requiring spinal surgery?
2. What is the cost-effectiveness of robotic-assisted surgical systems used for patients requiring spinal surgery?
Methods

Literature Search Methods
A limited literature search was conducted by an information specialist on key resources including MEDLINE, the Cochrane Library, the University of York Centre for Reviews and Dissemination databases, the websites of Canadian and major international health technology agencies, as well as a focused internet search. The search strategy comprised both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts were robotics and spinal surgery. No filters were applied to limit the retrieval by study type. Comments, newspaper articles, editorials, and letters were excluded. Where possible, retrieval was limited to the human population. The search was also limited to English-language documents published between January 1, 2017, and March 28, 2022.

Selection Criteria and Methods
One reviewer screened citations and selected studies. In the first level of screening, titles and abstracts were reviewed and potentially relevant articles were retrieved and assessed for inclusion. The final selection of full-text articles was based on the inclusion criteria presented in Table 1.

Exclusion Criteria
Articles were excluded if they did not meet the selection criteria outlined in Table 1, they were duplicate publications, or were published before 2017.

Table 1: Selection Criteria

<table>
<thead>
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<th>Criteria</th>
<th>Description</th>
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<tr>
<td>Population</td>
<td>Any patients requiring spinal surgery</td>
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<tr>
<td>Intervention</td>
<td>Spinal surgery (any spinal surgery, not including pedicle screw placement) using robotic-assisted surgical systems (e.g., MAZOR Robotic Guidance System)</td>
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<tr>
<td>Comparator</td>
<td>Conventional and traditional surgery performed without robotic-assisted surgical systems (including minimally invasive spinal surgery)</td>
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<td>Outcomes</td>
<td>Q1: Clinical effectiveness (e.g., postoperative functional status and mobility, range of motion, pain, length of hospital stay, health-related quality of life, patient satisfaction, blood loss, operative time, impact of anesthesia) and safety (e.g., rates of adverse events, hospital readmission, surgical revisions, complications [e.g., infections])</td>
</tr>
<tr>
<td></td>
<td>Q2: Cost-effectiveness (e.g., cost per quality-adjusted life-year gained, cost per health benefit gained)</td>
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<tr>
<td>Study designs</td>
<td>Health technology assessments, systematic reviews, and economic evaluations</td>
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Summary of Evidence

Quantity of Research Available
A total of 548 citations were identified in the literature search. Following screening of titles and abstracts, 531 citations were excluded and 17 potentially relevant reports from the electronic search were retrieved for full-text review. One potentially relevant publication was retrieved from the grey literature search for full-text review. None of these 18 potentially relevant articles met the inclusion criteria and were excluded for various reasons. Appendix 1 presents the PRISMA flow chart of the study selection. References of potential interest are provided in Appendix 2.

Summary of Findings
No relevant literature was identified regarding the clinical or cost-effectiveness of robotic-assisted surgical systems used for patients requiring spinal surgery that did not involve pedicle screw placement; therefore, no summary can be provided.

Limitations
Based on the findings of this report, published systematic reviews and economic evaluations regarding the clinical and cost-effectiveness of robotic-assisted surgical systems for performing spinal surgeries that do not involve pedicle screw placement seem to be lacking. This report is limited by the time frame used for literature searches (January 1, 2017, to March 28, 2022). It is possible that relevant literature published more than 5 years ago was excluded by the current date-limited search. A list of related publications that were not eligible for inclusion in this report due to their study design are provided in Appendix 2.

Conclusions and Implications for Decision- or Policy-Making
Conclusions could not be drawn regarding the clinical or cost-effectiveness of robotic-assisted surgical systems used for patients requiring spinal surgeries that do not involve pedicle screw placement because no literature that met the inclusion criteria for this report was identified.

It appears that the applications of robotic-guided systems in spinal procedures other than pedicle screw placement remain largely unexplored in clinical literature. Further research examining the clinical and cost-effectiveness of robotic-assisted surgical systems for these procedures is needed to investigate whether they are more effective than traditional methods and to inform decision-makers considering investment in these systems.
References


Appendix 1: Selection of Included Studies

Figure 1: Selection of Included Studies

- 548 citations identified from electronic literature search and screened
  - 531 citations excluded
  - 17 potentially relevant articles retrieved for scrutiny (full text, if available)
  - 1 potentially relevant report retrieved from other sources (grey literature, handsearch)
  - 18 potentially relevant reports
    - 18 reports excluded:
      - irrelevant intervention (7)
      - irrelevant comparator (1)
      - irrelevant outcomes (1)
      - other (review articles, editorials) (9)

0 reports included in review
Appendix 2: References of Potential Interest

Review Articles

Non-Randomized Studies