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Effectiveness of Neuromodulation in Postoperative Pain Management Following Spine Surgery: A Systematic Review

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 15 March 2025 and was last updated on 15 March 2025.

INTRODUCTION

Review question / Objective Population: Patients undergoing major lumbar spinal surgeries (lumbar fusion, decompression, laminectomy). Intervention: Neuromodulator Techniques. Comparison: Sham stimulation, no intervention, or standard postoperative pain management. Outcome: Postoperative opioid consumption and pain intensity scores (VAS, NRS).

Rationale Postoperative pain management following spinal surgery remains a significant clinical challenge, particularly given the high prevalence of lumbar spine surgeries and the risks associated with opioid-based analgesia. Despite advances in multimodal pain management, nearly 40% of patients undergoing spinal procedures experience failed back surgery syndrome. There is a need for alternative approaches. This is especially true considering the dangers of Opioids. utilization of opioids for alleviating pain in the postoperative phase presents considerable dangers, especially within the framework of the persisting opioid epidemic, which has underscored the pressing necessity for alternative pain management modalities. This need for data makes it crucial to study potential ajuncts.

Condition being studied The condition being studied is the post operative pain after lumbar spinal surgery.

METHODS

Search strategy A comprehensive search was performed in PubMed, MEDLINE, Google Scholar, ScienceDirect, and the Cochrane Library through late 2024 to identify relevant studies on neuromodulation techniques for postoperative pain management initially included broad terms such as "spinal surgery," "postoperative pain," "pain scale" and “neuromodulation” . Eligible studies examined neuromodulation techniques as part of postoperative pain management. Studies were excluded if they focused solely on pharmacological or surgical treatments without incorporating neuromodulation.

Participant or population Patients undergoing major lumbar spinal surgeries (lumbar fusion, decompression, laminectomy).

Intervention Neuromodulation including, but not exclusive to transcranial direct current stimulation (tDCS), repeated transcranial magnetic stimulation(rTMS), spinal cord stimulation (SCS), and transcutaneous electrical nerve stimulation (TENS).

Comparator There was a comparison group receiving either sham stimulation or a standardized postoperative pain protocol.

Study designs to be included Randomized Controlled Trials.

Eligibility criteria Studies were included if they evaluated patients undergoing major lumbar spinal surgeries such as lumbar fusion, decompression, or laminectomy. Eligible studies examined neuromodulation techniques as part of postoperative pain management, with a comparison group receiving either sham stimulation or a standardized postoperative pain protocol. The primary outcomes analyzed included postoperative opioid consumption, pain intensity (Visual Analog Scale [VAS], Numerical Rating Scale [NRS]), and safety parameters (adverse effects). Only randomized controlled trials (RCTs) were considered. Studies were excluded if they focused solely on pharmacological or surgical treatments without incorporating neuromodulation, investigated cervical spine surgeries, neuraxial anesthesia, or peripheral nerve blocks, examined physical therapy as the primary intervention, or were case reports, editorials, or narrative reviews.

Information sources This study used a systematic literature review approach and relied on multiple electronic databases to find Randomized Controlled Trails.

Main outcome(s) This table summarizes three studies examining the effects of transcranial direct current stimulation (tDCS) or transcutaneous electrical nerve stimulation (TENS)'s outcomes. The results suggest that motor/prefrontal tDCS and TENS may help reduce opioid usage, while anodal and cathodal tDCS over the dorsolateral prefrontal cortex (DLPFC) showed no significant effect.

Additional outcome(s) In tDCS there are no significant difference in mood or anxiety levels; No reported adverse effects.
There are no adverse events; however the second tDCS trial describes Mild side effects (tingling, burning, itching); Finally no need for rescue medications or no significant difference in postoperative nausea for TENS.

Data management Excel.

Quality assessment / Risk of bias analysis The methodological quality of each included study was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool, which evaluates randomization processes, allocation concealment, blinding of participants and outcome assessors, completeness of outcome data, and selective reporting We also used the Jadad score to assess internal validity, with scores ranging from 0 to 5, where higher scores indicate greater methodological rigor. Each study underwent an individual risk of bias assessment to ensure transparency and reliability in the evaluation process.

Strategy of data synthesis N/A.

Subgroup analysis N/A.

Sensitivity analysis N/A.

Language restriction No.

Country(ies) involved United States.

Keywords neuromodulation, postoperative pain, spinal surgery, lumbar spine surgery, pain management, opioid reduction, analgesia.

Dissemination plans The study will be submitted to a high-impact medical or pain management journal and hopefully used as the pilot for future research to establish future guidelines.

Contributions of each author
Author 1 - Rahul Venna - Author 1 drafted the manuscript and was one of the primary researchers searching for the articles and contributed to editing, reviewing, and updating paper.
Email: rrvenna@utmb.edu
Author 2 - Tomohiro Yamamoto - This author was one of the primary data collectors and helped with initial process of building the review. He reviewed it at the end.
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Author 3 - Adam Romman - One of the primary editors and reviewers. Reviewed full topic and used expertise on SCS and neuromodulation to provide insight.
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