Robotic-Assisted Muscle-Preserving (RAMP) Decompression in the Thoracic and Lumbar Spine: A Cadaveric Validation

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INTRODUCTION:
Laminectomy is widely performed, but traditional techniques often involve extensive muscle disruption and resection of stabilizing structures. Minimally invasive (MIS) approaches, such as “over-the-top” bilateral laminotomies preserve stability but still carry risks of neural injury, and may prolong operative time. Robotic-assisted (RA) systems are well-established for enhancing precision in pedicle screw placement, however their role in MIS decompression procedures, remains to be studied. This study aims to validate the accuracy and feasibility of robotic-assisted muscle-preserving (RAMP) decompression in thoracic and lumbar cadaveric models.
METHODS:
Eight human cadavers underwent 80 RAMP decompressions via a MIS approach, performing unilateral laminotomy with contralateral “over-the-top” decompression at ten levels (T8–L5) each, using a robotic bone removal instrument. Computed tomography (CT) was used for preoperative planning and radiographic evaluation of deviations at the posterior laminar bone removal site and the remaining anterior laminar cortex. Anterior cortical bone removals (ACBR) were classified as substantial if >3 mm ipsilaterally or >7.5 mm contralaterally.
RESULTS:
A total of 80 motion segments underwent RAMP decompressions (40 thoracic, 40 lumbar). The median deviation from preplanned trajectories to postintervention CT was 0.6 mm (IQR 0.3–1.2 mm) at the posterior laminar bone removal site and 0.2 mm (IQR 0.0–0.4 mm) at the anterior laminar cortex bilaterally following resection across all thoracic and lumbar levels. ACBR occurred in 41.3% (33/80), with only one being unplanned and substantial (1.25%). Ipsilateral ACBR accounted for 4 (12.1%), with a median deviation of 2.6 mm (IQR 2.1–3.4 mm), including one substantial and planned removal. Contralateral ACBR were more frequent (29, 87.9%) with a median deviation of 4.4 mm (IQR 2.7–6.3 mm), with four classified as substantial, three planned, and one unplanned.
DISCUSSION AND CONCLUSION: This study represents the first cadaveric validation of RAMP decompression across thoracic and lumbar levels, demonstrating the feasibility and precision of a specialized RA technique for controlled laminar bone removal. The minimal deviation between preplanned and postintervention trajectories underscores the procedural accuracy of RA guidance. Optimizing trajectory planning and robotic guidance may further reduce deviations and enhance procedural accuracy.