Minimally Invasive Separation Surgery with Intraoperative Stereotactic Guidance: A Feasibility Study

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■ BACKGROUND: **The treatment of spinal metastasis consists of algorithms combining surgical and radiation modalities. Recently the concept of separation surgery followed by stereotactic radiosurgery was shown to be a safe and effective treatment to achieve local tumor control.**

■ OBJECTIVE: **We examined a minimally invasive approach to separation surgery in a cadaveric study followed by a patient cohort with spinal metastasis using navigation to discuss our results and provide a technical note.**

■ METHODS: **A cadaveric study using minimally invasive access systems examined the feasibility of spinal cord decompression. Subsequently, 17 patients with spinal metastasis underwent minimally invasive separation surgery and instrumentation using navigation. All patients were at least 3/5 and pre- and post-operative CT scans were used to evaluate the decompression. Endpoints included neurologic function, operative time, estimated blood loss, duration of hospital stay, and complications.**

■ RESULTS: **The cadaveric study demonstrated adequate decompression of the spinal cord. For the operative cases, the post-operative imaging demonstrated excellent separation for safe stereotactic radiosurgery. The mean incision length was 4.9 cm. The average operative time was 6 hours and 48 minutes, the mean length of stay was 12.8 days and the mean surgical blood loss was 458 mL. The median Spine Instability Neoplastic Score score was 10 with a range of 6–16. All patients remained or improved their neurologic baseline with excellent pain control. One patient incurred a perioperative complication.**

■ CONCLUSIONS: **Minimally invasive separation surgery for spinal metastasis allows for circumferential decompression of the spinal cord and safe post-operative stereotactic radiosurgery. In addition, we demonstrated the efficacy of intra-operative navigation in guiding the resection.**

INTRODUCTION

The treatment of spinal metastasis has evolved over recent years to encompass a multidisciplinary approach to establish treatment options that allow for individualized care using standardized algorithms. Surgery, radiation, and chemotherapy play adjuvant roles in the treatment of spinal tumor diseases. As a result, the prognosis and life quality of patients with spine metastases have improved.[1] Each of these treatment algorithms has had its own independent evolution and with new individual advances and paradigm shifts, the overall clinical prognosis evolves.[2] With improvements in systemic therapy of malignancy, effective radiologic and surgical management of spinal metastases has become increasingly important.[1] The goals remain to provide spinal stabilization and maintain neurologic function, tumor control, pain relief, and longevity, with improvement of quality of life.[3]

Key words
- Minimally invasive
- Separation surgery
- Spinal oncology
- Stereotactic navigation

Abbreviations and Acronyms
IAP: Inferior articulating process
MISS: Minimally invasive separation surgery
SAP: Superior articulating process
SINS: Spine Instability Neoplastic Score
SRS: Stereotactic radiosurgery
TP: Transverse process

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Although historically external beam radiation therapy was the treatment option of choice for spinal metastases, it had the disadvantages of poor control of radioresistant tumor histologies and dosing limitations secondary to radiation injury to the spinal cord.[4] The development of stereotactic radiosurgery (SRS) provided an attractive alternative to external beam radiation therapy by allowing the delivery of high-dose radiation in single fractions in combination with a steep dose gradient that may be conformed around the spinal cord and hence minimize side effects.[4,5] In the setting of spinal metastatic lesions, SRS has been proved to obtain excellent local tumor control.[6,7] SRS delivered after surgery for metastatic epidural spinal cord compression reported rates greater than 90% for local control, independent of tumor histology.[8]

The benefits of surgery for metastatic epidural spinal cord compression have been elucidated in many studies.[1,9,10] Although surgical decompression followed by instrumentation to maintain stabilization has been shown to have favorable neurologic outcomes,[1,9,11,12] clear guidelines and algorithms had to be established to determine when surgery would be most beneficial. The Neurologic Oncologic Mechanical Systemic framework and Spine Instability Neoplastic Score (SINS) were established to help guide the selection of surgical candidates by evaluating neurologic and oncologic parameters and mechanical instability, as well as the systemic disease burden.[12-15] With the advent of SRS, surgery may be complemented with higher-dose, disease-independent, adjunctive radiation treatment.[5] Surgery with adjuvant radiation therapy has been shown to be a safe and effective method of treating spinal metastases with favorable results.[3,16,17] The advancement of SRS has influenced and guided the changes in the surgical techniques used for the management of spinal tumors and has led to the development of separation surgery.[13,16,17] Separation surgery derived from the idea that the recreation of a minimum amount of space between the tumor and the spinal cord without extensive tumor debulking and reconstruction would allow for safe radiation treatment without the morbidity of a traditional open decompression, reconstruction, and instrumentation.

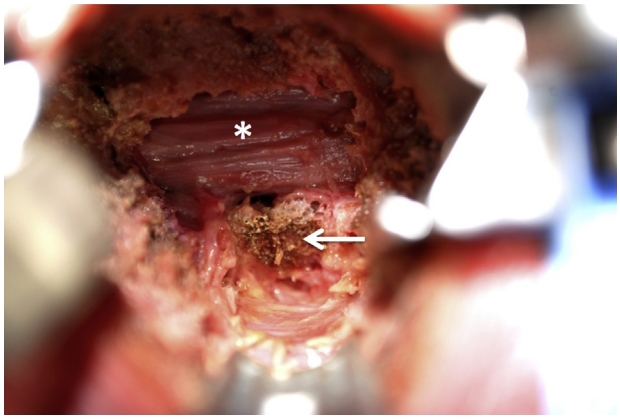

Figure 2. The inferior articulating process, lamina, facet joint, and residual transverse process are resected, exposing the underlying dura (*). The pedicle is identified for the subsequent transpedicular approach (←).

Furthermore, intraoperative navigation has become increasingly commonplace in spinal surgery. A recent study[18] showed the usefulness and feasibility of intraoperative stereotactic navigation in the resection of spinal tumors. In the current study, we examined the possibility of coupling our advancement in minimally invasive techniques and intraoperative navigation technology with the surgical treatment of spinal tumors. A less invasive surgery, if technically feasible and safe, could further minimize tissue dissection. Together with SRS, stereotactic navigated minimally invasive separation surgery (MISS) would allow for local tumor control, spinal stabilization, and maintenance of neurologic function as well as pain control in patients with spinal metastases and potentially decrease the morbidity associated with traditional open surgery. We first examined the technical achievability of MISS in a cadaveric study and then translated the technique into a clinical setting for a feasibility study.

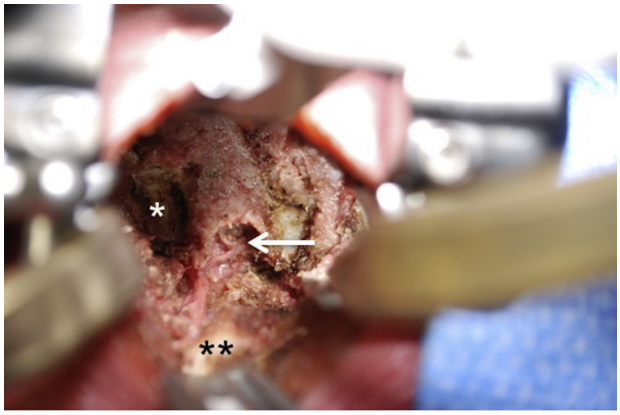

Figure 1. The retraction system is placed and after visualization of the anatomic landmarks, the inferior articulating process is removed, exposing the underlying superior articulating process (*). The costotransverse joint is drilled (**) to optimize the lateral exposure and the pedicle is identified (←).

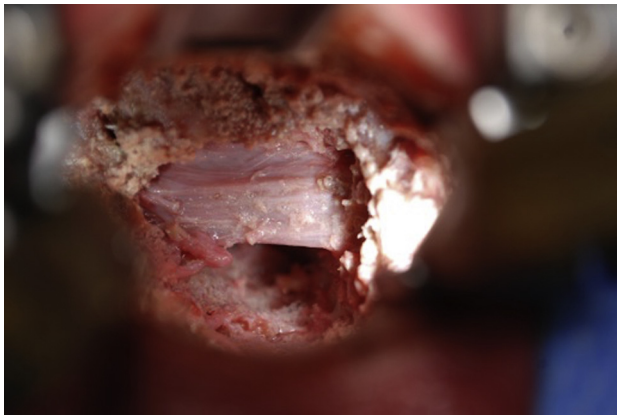

Figure 3. The transpedicular approach allows for a decompression of the anterior area of the thecal sac. The thecal sac is hence decompressed posteriorly, ipsilaterally, and anteriorly.