Separation Surgery for Spinal Metastases: A Review on Surgical Treatment Goals

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ABSTRACT

Spinal metastases occur in nearly half of all patients with cancer and may cause instability, intractable pain, and neurologic injury secondary to epidural spinal cord compression (ESCC). A multidisciplinary approach to these patients is critical, and surgery must always be considered. Circumferential decompression and stabilization, if necessary, preserves short term function while creating borders between neural elements and metastatic tissue. After surgery, stereotactic radiotherapy can be delivered, which may achieve local control rates of nearly 80% at 2 years depending the underlying tumor etiology. In this review, we aim to elucidate the surgical decision-making and goals for separation surgery in patients with ESCC.

KEY WORDS: Separation surgery, Spinal cord compression, spinal metastases, spinal radiosurgery

INTRODUCTION

Metastatic Spinal Disease

Spinal metastases are estimated to occur in 40% of all patients with cancer (21). Metastatic disease can cause spinal instability, spinal cord compression which can lead to neurologic injury, and pain (12,20,28). Epidural spinal cord compression (ESCC) affects up to 10% of all patients with cancer and approximately 8,000 admissions annually occur from spinal cord compression according to the nationwide inpatient sample (17,21,29). In patients with spinal cord compression, preservation of neurologic function is the goal of treatment to maintain quality of life.

A multidisciplinary approach to patients with ESCC is critical. In addition to systemic therapy, surgical and radiotherapy are often needed to preserve quality of life. In a randomized controlled study of surgical decompression with conventional radiotherapy, Patchell et al, demonstrated superiority of combined surgery and radiotherapy for recovery and maintenance of neurologic function and survival (22). While surgery provides spinal stabilization and neural element decompression, prompt radiotherapy can lead to long-term local tumor control as low as 18% for even radioresistant tumors (6,10,18,23).

Stereotactic Radiosurgery

Stereotactic spinal radiosurgery (SRS) and external beam radiotherapy (EBRT) have emerged as the mainstay of treatment for metastatic disease to the spine. EBRT has shown histology-specific sensitivity. Radiosensitive malignances such as lymphoma and multiple myeloma have 2-year local control rates of up to 80 to 90%, however, radioresistant tumors such as renal cell carcinoma or melanoma may be as low as 30% (9,13,18). The emergence of high-dose hypofractionated SRS has revolutionized radiotherapy for metastatic lesions. Gerszten et al, treated spinal metastases without epidural extension using multi- and single-fractionated SRS each demonstrating 90% and 70% local disease control for cases of failed EBRT and first-line therapy (10). One cohort of radiosurgery for ESCC
Surgical approach is dictated by the location of the epidural disease (Figure 1A-F). Dorsal epidural decompression can be achieved via wide laminectomy, however, ventral and lateral decompression often warrants removal of posterior elements and may require stabilization. Wide unilateral or bilateral transpedicular approaches with a high-speed drill allows maximal exposure of ventral, lateral, or circumferential epidural tumor without manipulation of the spinal cord (Figure 1). In the thoracic spine, nerve roots below T1 can be sacrificed to improve exposure. Once lateral decompression is adequate, the posterior aspect of the vertebral body can be resected to allow for down-going curettes to be used to push any remaining epidural tumor away from the thecal sac. In cases with severe destruction of the vertebral body, anterior reconstruction may be necessary for stabilization.

**Spinal Instrumentation**

Posterior spinal instrumentation should be considered when posterior element resection is performed, in cases of instability, or in select cases prophylactically (Figure 2A-F). The Spinal Instability Neoplastic Scores (SINS) is a validated decision-making tool, which can help surgeons preoperatively determine if stabilization is needed (Table 2) (5,7,8,16).

Moussazadeh et al, examined 318 patients who underwent decompression and fixation without anterior reconstruction at their institution over a 7 year period from 2004 to 2011. The median follow-up time was 399 days and only 9 patients (2.8%) demonstrated hardware failure. Patients with chest wall resection and construct length longer than six contiguous spinal levels exhibited a statistically significant higher risk of hardware failure. Thus, instrumentation of at least two levels above and below is recommended in most cases and has been shown to low rates of hardware failure. Cross-links should be avoided to prevent scatter artifact during treatment. Bioactive materials to promote fusion after stabilization are avoided in these patients secondary to the adjuvant radiation that will be delivered.

Due to radioresistant lesions described a 65% reduction in tumor volume at 2 months and 81% rate of improvement in function at 12 month follow-up (24-26). This data suggests SRS is capable of achieving local control rates for refractory cases to EBRT or as first-line therapy for radioresistant tumors.

**Separation Surgery**

The hallmarks of separation surgery are to decompress the neural elements away from epidural encroaching disease of at least 2-3 millimeters prior to radiotherapy. Patients with acute neurologic decline and a known lesion should be considered for urgent decompression immediately if medically cleared. However, surgical treatment for ESCC without neurologic deficits remains a point of debate. The ESCC scale developed by Bilsky et al, provides a common vocabulary to stratify patients based upon “low-grade” versus “high-grade” compression radiographically (Table 1) (1-3,19). Surgical decision-making must take into account the radiosensitivity of the known primary, stability of the lesion, and overall prognosis of the patient (11,12,14,15,19).

In high grade lesions, neurologic compromise may be imminent and SRS can take up to 2 months to show tumor volume reduction. Thus, these patients should be considered for decompression at least to avoid neurologic compromise and preserve quality of life.

Lesions abutting the spinal cord but without true circumferential compression present a dilemma as SRS can be toxic to neural elements at high doses. Sahgal et al, have shown radiation induced myelopathy can occur with as low as 10-14Gy per single fraction of radiation delivered when ESCC is present (27). EBRT can be delivered safely, however, radioresistant tumors such as renal cell carcinoma or melanoma may be refractory in many instances. By achieving separation of just 2-3 millimeters, tumoricidal radiation doses can be delivered safely in these select patients. Thus, surgery should be considered in patients with lower grades of ESCC if SRS is necessary.

**Table 1: Epidural Spinal Cord Compression Scale**

<table>
<thead>
<tr>
<th>Grade 0</th>
<th>Bone-only Disease</th>
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<tbody>
<tr>
<td>Grade 1a</td>
<td>Epidural Disease without Thecal Sac Compression</td>
</tr>
<tr>
<td>Grade 1b</td>
<td>Deformation of Thecal Sac</td>
</tr>
<tr>
<td>Grade 1c</td>
<td>Deformation of Thecal Sac and Spinal Cord Abutment</td>
</tr>
<tr>
<td>Grade 2</td>
<td>Spinal Cord Compression with CSF visible</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Spinal Cord Compression without CSF visible</td>
</tr>
</tbody>
</table>

“Low-Grade ESCC”

“High-Grade ESCC”
Figure 1: Epidural Compression. Axial images displaying epidural mass lesions causing dorsolateral (A), ventral (B), and circumferential (C) compression of the thecal sac and spinal cord. D-F: Surgical Approaches. Wide laminectomy (D) with resection of laminae as well as the medial facet joints is shown for dorsal epidural compression. Unilateral transpedicular approach (E) with resection of laminae as well is shown for ventrolateral epidural compression. Bilateral transpedicular approach (F) with resection of laminae as well as both pedicles is shown for circumferential compression.

Figure 2: 72 year-old male with salivary gland myoepithelial carcinoma refractory to initial radiotherapy with worsening of pain and sudden neurologic decline. Preoperative MRI with Gadolinium T1 Sagittal and Axial (A and B) and Axial T2 (C) images demonstrated high grade cord compression. He underwent a T6-T10 posterior decompression and instrumentation with right sided T8 transpedicular approach for ventral tumor separation. Patient tolerated the procedure well and returned to full strength postoperatively. MRI with gadolinium T1 Sagittal and Axial (D and E) and T2 Axial (F) confirmed adequate decompression and separation making him a candidate for SRS postoperatively.
Vertebral compression fracture (VCF) after SRS for spinal metastases has been estimated to occur between 10-39% of cases (4). Boehling et al, reviewed 123 vertebral bodies in 93 patients prospectively who received SRS in 1, 3, or 5 fractions. They found 20% of patients developed VCF after SRS. The most common histology for fracture was renal cell carcinoma (10/36, 28%) in their study. This data suggests prophylactic spinal stabilization at the time of separation surgery may be warranted for certain histologies, but further research must be performed to make concrete conclusions.

Post-operatively, CT myelography or high resolution MRI should be performed for procedural planning and simulation for treatment. EBRT, single- or multi-fractionated SRS should be planned and prescribed prior to discharge. Bilsky et al described 186 patients treated with decompression separation surgery followed by adjuvant hypofractionated or single dose SRS with 136 having “high-grade” cord compression. Patients received hypofractionated SRS within 1.6 months following surgery and cumulative local progression at 1 year was 16.4% (13). This data suggests excellent local control rates if prompt radiotherapy can be delivered after separation surgery is performed.

**CONCLUSIONS**

For patients with ESCC, surgical considerations must take into account neurologic status, primary histology, patient prognosis, and radiotherapy options available to the patient. In patients with neurologic decline, urgent decompression must be considered. SRS requires separation 2-3 millimeters to be performed safely. Outside of select instances of radiosensitive tumors, separation surgery should be considered for ESCC abutting the spinal cord. Stabilization following decompression is necessary in most cases and should be performed posteriorly in the majority of cases. A multidisciplinary approach to this patient population is critical to maintain quality of life and improve survival. Patient selection is critical to give patient's access to optimal medical and surgical management moving forward. Prospective studies on adjuvant radiotherapy timing and dosing for different histologies is the frontier and must be performed to create treatment paradigms unique to specific patient populations.

**REFERENCES**


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