Laser interstitial thermotherapy for epidural tumor decompression: is there a role?

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Tatsumi et al. present a pilot study of patients treated with spine laser interstitial thermotherapy (SLITT) to treat the epidural component of metastatic spine tumors in which they create a safe distance from the spinal cord for the administration of adjuvant stereotactic radiosurgery (SRS). Spine laser interstitial thermotherapy involves the percutaneous placement of laser probes into the posterior vertebral body that ablate the epidural tumor while monitoring critical temperatures using MR-generated thermal images. The authors’ paper presents a new modality that has the potential to significantly impact the treatment of spine metastases.

In treating metastatic spine disease, it is critical to understand that the principal roles of surgery are spinal cord decompression and spine stabilization. Similar to the limitations encountered in treating malignant brain tumors, local tumor control for spine metastases is minimally impacted by surgery; rather it is predicated on the delivery of effective radiation or systemic therapy. With the exception of hematological malignancies, most spine tumors do not respond to systemic therapy. Radiation therapy remains the mainstay of treatment for achieving local tumor control whether used as definitive therapy or as a postoperative adjuvant. The evolution of spine SRS has substantially improved response rates for metastatic solid tumor malignancies, compared to those following conventional external beam radiation (cEBRT). Gerszten et al. performed a systematic Cochrane review of the literature in which SRS was recommended over cEBRT for the treatment of radioresistant malignancies in which no relative contraindication exists. The most significant contraindication to using SRS as definitive treatment is high-grade epidural spinal cord compression (ESCC), which prohibits delivering a cytotoxic dose to the tumor while remaining within the constraints of spinal cord tolerance. Thus, surgical techniques such as separation surgery have been developed to limit tumor resection to the epidural space in order to reconstitute the thecal sac, followed by long posterior segmental fixation, without incurring the additional morbidity from resection of the vertebral body or paraspi nal masses. Laufer et al. reviewed a series of 186 patients in whom separation surgery was followed by SRS, reporting a cumulative incidence of local recurrence of less than 10% at 1 year with the use of either high-dose hypofractionated (24–30 Gy in 3 fractions) or single-fraction (24 Gy) SRS that was independent of tumor histology, prior failed radiation, or the degree of preoperative ESCC.

The application of SLITT presents an opportunity to further reduce the potential morbidity of separation surgery by using percutaneous laser interstitial therapy to provide room for adjuvant SRS rather than open posterolateral decompression. In the current series from MD Anderson, 11 patients with ESCC scores ranging from 1c to 3 and without neurological deficits were treated with SLITT to decompress the spinal cord, followed by high-dose single-fraction or hypofractionated SRS with a cord constraint of 12 Gy. All tumors were radioresistant, most commonly renal cell carcinoma, and all patients had medical comorbidities or advanced disease that precluded open surgery. On average, 36% of the tumor area was ablated with a mean 28% reduction in the thickness of the epidural tumor and a median reduction in the ESCC score from 2 to 1b. All patients had a Frankel Grade E in the pre- and postoperative periods. The median postprocedure hospital stay was 2 days, and the median follow-up was 4.7 months. None of the patients had evidence of tumor recurrence at the last follow-up. One patient with recurrent sarcoma at C-2 experienced paresthesias and decreased temperature perception without motor deficits, which resolved within 4 weeks. One patient who was on bevacizumab had a wound dehiscence at the site of the spinous process clamp used for navigation, and one patient developed mechanical instability after ablation of an L-3 renal cell metastasis and required open surgery for stabilization. The mean VAS...
score decreased from 6.2 preoperatively to 2.8 within 60 days of surgery.

Spine laser interstitial thermotherapy holds great promise in selected cases, but a number of limitations exist. The authors’ study clearly demonstrates that this minimally invasive technique can be used to decompress the spinal cord providing room for high-dose SRS with relatively limited morbidity. The technique can be combined with percutaneous pedicle screws or delayed cement augmentation to provide stability when indicated. Hospital stays were very short, and patients should be able to return to systemic therapy quickly. However, wide applicability of this technique is limited by the availability of intraoperative MRI, experience with precision image guidance of laser probes, and familiarity with the use of thermal ablation techniques. Despite being minimally invasive, SLITT takes an extremely long time, requiring 8 hours of anesthesia time compared to less than 3 hours for separation surgery. These impediments to treatment will clearly improve with more experience and further refinements in the technique. The treatment seems best suited for reducing anterior tumor confined by the posterior longitudinal ligament, but spinal cord compression is often lateral, posterior, or circumferential; thus, the anatomy of ESCC may preclude effective decompression using SLITT in many cases. Additionally, subaxial cervical tumors cannot currently be treated using this technique. In the authors’ study, the long-term local tumor control and improved SRS dose coverage of the tumor volume following SLITT are not available but would be helpful in future publications for determining durability and effectiveness. Ultimately, there may be fewer indications for SLITT (and separation surgery) with refinements in the definition of spinal cord tolerance and the improved therapeutic window provided by high-dose hypofractionated compared to single-fraction radiation.

Despite these limitations, the authors of this study are to be congratulated on the application of this existing technology in a unique and potentially revolutionary way that makes sense in the context of a patient’s metastatic disease and the growing body of evidence demonstrating excellent tumor control using SRS without the need for aggressive resection. Spine laser interstitial thermotherapy is a novel, minimally invasive decompressive technique for spine tumors. We look forward to further developments in this technique with the hope and expectation that this will be a valuable tool in the treatment of metastatic spine tumors.

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References


Response
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We sincerely thank Drs. Bilsky and Laufer for their careful and insightful comments regarding our study. The philosophy behind the development of SLITT is heavily based on their publications and contributions to the field of spine oncology.1,2,7,8

Since the seminal publication of Patchell et al.,10 surgical decompression with spinal stabilization followed by radiation therapy has been the standard of care for the management of metastatic spinal cord compression. Over the last 10 years, spinal SRS (SSRS) has emerged as a powerful tool in the treatment of spinal metastasis. However, the major series reported in the literature were published prior to 20111,5,6,9,11 and reflect the experience of different centers using different contouring, hypofractionation regimens, and constraints to limit the radiation to the spinal cord. It is undeniable that a high rate of local control can be achieved with SSRS, but the extension of tumor to the epidural space constitutes a high risk factor for treatment failure.5 A major contribution of Drs. Bilsky and Laufer to the field is the introduction of the ESCC scale (frequently referred to as the “Bilsky classification”).3 Unfortunately, most SSRS series reporting excellent local control did not stratify the results by the degree of ESCC. Our current practice is to limit the maximal dose (Dmax) to the spinal cord to 12 Gy (0.01 cc = 12 Gy) in patients treated with 1 fraction of SSRS. The dose falloff beyond the radiation target is approximately 2 Gy/mm. Since the minimal effective dose to the tumor (Dmin) is considered to be 15–16 Gy, in a tumor abutting the spinal cord, there will be a 3- to 4-mm area in the epidural space underdosed to respect spinal cord tolerance. This forms the rationale for performing separation surgery before SSRS.1,2,7,8 Unfortunately, surgical morbidity is multifactorial and can be prohibitive in patients with advanced cancer. Even a rapid decompression and stabilization can be futile in the setting of extensive systemic disease, when patients have to recover from surgery prior to receiving adjuvant treatment. Poor wound healing, deconditioning, and malnutrition can negatively impact patient survival. The development of SLITT comes as an alternative to achieve separation or epidural tumor destruction as an adjunct to SSRS, with lower morbidity than open surgery.

We are in full agreement about the limitations of our technique as described by Drs. Bilsky and Laufer. However, our report represents our early experience with the technique. We have treated another 14 patients since we wrote our paper, and we have significantly improved the surgical workflow. Our median operating time for the last
10 cases has been 6 hours (2 hours less than in our initial report). And we believe that this time can be reduced to 3 hours with improvements in registration for spinal navigation and by performing a simultaneous ablation using 2 fibers at the same time, which is currently not possible. Regarding the comment about epidural tumor location, we have applied the Weinstein-Biagini-Boriani classification for trajectory planning, and we have successfully treated epidural tumors with a lateral location (Zones 3–5 or 8–10) using a vertical transpedicular approach, those with a posterior location (Zones 10 to 3) using a contralateral translaminar approach, and even those with circumferential dural compression using a combination of approaches. An analysis of trajectories, improvements in technique, local control, clinical results, complications, and failures in this larger cohort of patients will be provided in a future publication. We are planning an institutional Phase II study to assess local control and clinical outcomes of patients undergoing SLITT prior to SSRS. We will be using a recently completed institutional Phase I trial in patients with epidural tumor treated purely with SSRS in which the spinal cord tolerance was relaxed to up to 16 Gy as a historical control. We believe that the results of this study will shed light on the role of SLITT in the treatment of metastatic spinal tumors.

References