Current Treatment of Metastatic Spine Tumors – Surgery and Stereotactic Radiosurgery

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ABSTRACT

There has been significant progress and innovation in the treatment of patients with metastatic spinal tumors over the last two to three decades that has impacted our ability to provide individualized care that improves a patient's quality of life and degree of neurologic impairment. Advances in surgical techniques and radiation delivery modalities have dramatically improved our ability to decrease local tumor recurrence rates, improve pain control, and provide more durable spinal stability. Modern day spine tumor resection and reconstruction techniques have been shown to improve and prolong patients' ability to ambulate, maintain continence, and reduce the need for pain medications. Spinal radiosurgery, the focused delivery of radiation to a target in the spine, has significantly enhanced the ability to provide a high degree of local tumor control in a non-invasive manner, even for tumors that are deemed radioresistant by conventional radiation therapy standards. In most patients, a combination of treatment modalities, including both surgery and radiation, is the mainstay of any comprehensive treatment plan for metastatic spinal tumors.

KEYWORDS: spine metastases, separation surgery, spinal radiosurgery, spine tumor, spine decompression

INTRODUCTION

Metastases are the most common spine tumor, with up to 40% of cancer patients developing spinal metastases, and 5-10% developing symptomatic epidural spinal cord compression.[1] The spine is the most common site of skeletal metastases, with the thoracic spine being the most frequently involved spinal segment, followed by the lumbar and cervical spine. Advances in the treatment of cancer has led to improved patient survival, but also a higher incidence of patients with spinal metastases. The treatment of these patients has evolved substantially over the past several decades, with dramatic advances in both surgical and radiation therapies. In this paper, we summarize some of the more important advances in these respective fields.

SURGICAL ADVANCEMENTS

For many years, patients with metastatic spine tumors causing epidural spinal cord or nerve root compression were treated with simple posterior spinal decompression followed by fractionated external beam radiotherapy. While some patients did improve in terms of ability to ambulate and bowel/bladder function,[2] the results weren't encouraging. When compared to radiation alone the addition of a simple posterior decompression was not found to add any significant benefit in terms of pain, sphincter function, or improved ambulation.[2] The disheartening results of such studies led to a decline in surgical intervention.

The primary problem with a simple posterior decompression of the spinal cord, which is typically done via laminectomy, is that in many patients, epidural compression is ventral to the spinal cord, not dorsal. This means that many patients continue to have ventral spinal cord compression despite a posterior decompression. Following the disappointing outcomes of earlier studies examining laminectomy and radiation for tumor treatment,[2] surgeons began developing techniques to directly decompress the spinal cord with ventral tumor resection. The hope was that circumferential decompression of the spinal cord with instrumented stabilization of the spine might lead to improved outcomes. This was confirmed in a landmark randomized, prospective trial published in 2009 by Patchell et al. comparing radiation alone to radiation plus circumferential surgical decompression in patients with a single spinal metastasis compressing the spinal cord.[3] The authors found that 84% of patients treated with both circumferential decompression and radiation were able to ambulate after treatment versus 57% patients who underwent radiation alone. In the group of patients unable to walk before treatment, 62% in the surgery group regained the ability to ambulate versus 19% in the radiation only group. This contrasts with the results of performing a laminectomy alone with radiation in the study by Young et al. in which 45% of patients were able to ambulate after treatment.[2] The surgery plus radiation group was also able to walk for a longer period of time after treatment versus the radiation only group (122 days vs. 13 days). This study provides the best evidence to date that circumferential spinal cord decompression can significantly improve patient quality of life.

Pathologic fractures in patients with metastatic spine

tumors without epidural compression often present with significant back pain. When unstable these fractures tend to be managed via surgical instrumentation. However, when neither gross instability nor significant epidural spinal cord compression exist, percutaneous vertebral body cement augmentation is a non-invasive method that can provide back pain relief. There are two primary methods of cement augmentation: balloon kyphoplasty and vertebroplasty, both of which have been shown to be effective for treating pain from pathologic fractures.[4] These procedures involve injection of polymethylmethacrylate (PMMA) through the percutaneous insertion of a small metal trocar into the vertebral pedicle, followed by injection of cement under fluoroscopic guidance. With balloon kyphoplasty, a small inflatable balloon is inserted into the vertebral body and inflated to augment vertebral body height prior to injection of cement. Even in patients with significant vertebral body collapse, cement augmentation can be an effect option for pain relief, with a low overall complication rate.[5]

ADVANCES IN RADIATION TREATMENT

Radiation delivery for spinal metastases has evolved substantially since the end of the 20th century. Traditional external beam radiation therapy (EBRT) consists of radiation delivered in a fractionated dose, typically 30 Gy over 10 fractions, and using simple one to two portal configurations that encompasses the area of disease with a wide margin of 1 vertebral level above and below. EBRT has been shown to be effective in treating very radiosensitive tumors such as multiple myeloma and lymphoma as well as moderately radiosensitive tumors such as breast and prostate cancer.[6,7] However, EBRT has been shown to not be as effective in the treatment of more radioresistant tumors, such as sarcoma, melanoma and renal cell carcinoma.[6,7] To maximize the dose of radiation delivered to a tumor target and minimize radiation toxicity to surrounding healthy tissues, advances in both computing hardware and radiation planning software were incorporated into treatment planning. This led to the development of conformal radiotherapy such as intensity modulated radiation therapy (IMRT), which utilizes sophisticated 3D planning and multi-leaf collimators that focus radiation to the intended tumor target and minimize dose to adjacent normal tissues. However, the radiation sensitivity of the spinal cord and its intimate location to metastatic disease in the vertebra, limits the safe delivery of only moderate doses of radiation (45-50Gy in standard fractionation) with this technique.[8]

The next significant advance in radiation therapy was the development of stereotactic radiosurgery to be delivered to spine lesions akin to stereotactic radiosurgery for brain metastases in the late 20th century. Radiosurgery consists of a single or hypo-fractionated dose of radiation delivered with extreme precision to the tumor target. Unlike cranial stereotactic radiosurgery, spinal radiosurgery has unique technical obstacles. This includes dose limitations due to proximity of the spinal cord and spinal motion during radiation delivery. Unlike the head, which can be fixated in place using a stereotactic frame, the spine is more difficult to constrain. To overcome the problem of motion, immobilization devices coupled with real-time image guidance during treatment have been developed which allow for targeting accuracy to 1mm or less. The extreme precision combined with sophisticated dose modulation allows for the delivery of high doses of radiation while still relatively sparing the spinal cord. This results in safe delivery treatment that is effective even for radiation-resistant histologies. Using single fraction dose equivalents of 18-24 Gy, studies have demonstrated a local tumor control rate of 80-96%,[9-11] and a 86% chance of long-term pain relief.[12]

A NEW PARADIGM

The success of spinal radiosurgery in terms of local control and pain relief of spinal tumors has dramatically altered treatment paradigms. It has supplanted both EBRT and surgery in the primary treatment of solitary spine tumors without significant epidural compression. In those patients with significant neural element compression, or in those patients with spinal instability due to an unstable pathologic fracture, surgery remains the gold standard. Similarly, EBRT continues to be used for the treatment of radiosensitive spinal metastases. To minimize surgical morbidity from an extensive circumferential decompression including vertebral body resection, Laufer et al have advocated 'separation surgery' which entails circumferential resection of epidural tumor, a limited resection of vertebral body tumor, followed by adjuvant radiosurgery to the remaining tumor and resection cavity.[13] In their series of patients, Laufer et al reported a 4.1 – 22.6% local recurrence rate at 1 year depending on the radiation dose/fraction regimen utilized post-operatively. Despite these impressive results, further study is needed to determine whether this is a more efficacious strategy versus a more aggressive surgical resection and spinal reconstruction.

CONCLUSION

Recent advances in the surgical and radiation management of patients with spinal metastases has led to significant improvement in patient outcome. Despite these advances, treatment remains palliative. The goals of care should be to minimize patient morbidity, and maximize patient quality of life in terms of pain, mobility, and neurologic function. A multi-disciplinary approach to management of these patients that incorporates medical oncology, radiation oncology, and neurosurgery is necessary for optimal treatment planning in this complicated group of patients.

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