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Low-Dose Beta Emitting Membrane-Like Brachytherapy: A Cadaveric Study and Simulation of a Novel Anisotropic Dose Delivery Solution for Metastatic Spine Disease

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Abstract

Objectives:

Beta emitting brachytherapy has demonstrated efficacy in treating metastatic disease to the spine. Radiation dosing to non-neurologic structures adjacent to the spinal cord is often sub therapeutic due to concerns of radiotoxic surrounding spinal cord structures. Thus, tumor recurrence is frequently observed in the posterior vertebral body and pedicles, where radiation therapy is less aggressively administered. We evaluate the theoretical efficacy of a low-dose beta emitting membrane-like brachytherapy device in providing adequate radiation to the bony structures while preserving key neurologic structures through anisotropic dose distribution in this cadaveric study.

Methods:

Methods:

A single cadaver prepared for surgical dissection and placement of device. Following surgical exposure of the spinal cord, contoured a low-dose beta emitting membrane-like brachytherapy device was placed in the lumbar and sacral spine anterior to the spinal cord and nerve roots respectively utilizing fluoroscopy to optimize placement. An absorbable hemostatic agent was placed between the device and the spinal cord. 4mm CMF screws anchored to the vertebral body were used to hold the device in place. The cadaver was then sent for Radiographic (XR), Computed Tomography (CT), and Magnetic Resonance Imaging (MRI). Simulated radiation planning was performed using Eclipse and MIM software.

Results:

Results:

The low-dose beta emitting membrane-like brachytherapy device and the associated hemostatic agent dorsal to the device was placed without trauma to the spinal cord or nerve roots. The absorbable hemostatic agent increased the distance between the emitting particles and the spinal cord to reduce cord dosing. There was minimal artifact on XR, CT, and MRI. The device contained 14 sources with an observed 6.10mCi per source. Simulated radiation trials yielded anisotropic radiation dose. There was a total of 47 Gy at a 5 mm depth into the posterior vertebral body with Cauda max voxel (0.03cc) of 3.5Gy. Spinal cord and cauda dose was subtherapeutic.

Conclusion(s):

Conclusion:

The use of low-dose beta emitting membrane like brachytherapy may demonstrate efficacy in providing appropriate radiotherapy through anisotropic dosing of radiation. Placement of this device anterior to the spinal cord yielded therapeutic doses of radiation to the vertebral body while maintaining subtherapeutic doses to the spinal cord. This therapy in combination with Stereotactic Radiosurgery would provide improved radiation coverage of the epidural space and dorsal vertebral body.