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# Evaluation of Minibeam Treatment Delivery Techniques for Target Dose Uniformity

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Abstract
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## Abstract

Objectives:

Minibeam radiation therapy (MBRT) is a type of spatially fractionated radiation therapy (SFRT) that utilizes small radiation beams roughly one millimeter in size adjacent to areas of low dose. MBRT has been shown to increase dose tolerances in animal studies, allowing for large doses to be delivered with minimal toxicity. This is beneficial in healthy tissue but not ideal for treatment target volumes which require a more uniform dose for tumor control. The objective of this work is to evaluate different MBRT treatment delivery techniques using a previously validated MBRT delivery system to compare target coverage and target hot spots for the different delivery techniques.

Methods:

A hexagonal MBRT collimation system with 1.5 mm diameter openings and a 4 mm center-to-center (ctc) spacing was previously validated with radiochromic film dosimetry and Monte Carlo simulation studies on a commercially available small animal irradiator. A simple geometry consisting of a 10x10x10 mm3 water-equivalent target volume inside a 50x50x50 mm3 water-equivalent cube was used for a Monte Carlo simulation treatment planning study. Dose distributions within the target volume were calculated with a 0.5x0.5x0.5 mm3 dose grid with varying numbers of fields. Dose normalization was performed such that the mean dose to the target volume was set at the 100% dose level. The volume receiving 100% of the dose (V100%), volume receiving 90% of the dose (V90%), and dose received by 10% of the volume (D10%) were determined to quantify the target coverage and target hot spot in the calculated dose grids.

Results:

Single isocenter plans were calculated with 1, 2, 3, 4, 5, and 7 beams with even spacing between gantry angles. V100% values ranged from 20.0% to 38.3%, V90% values ranged from 20.1% to 41.7%, and D10% values ranged from 222.6% to 347.2%. The 7 beam field arrangement resulted in the largest V100% and V90% and the lowest D10%. An additional 7 beam plan was calculated with a 45-degree collimator rotation for 3 of the 7 beams which improved the V100% from 38.3% to 42.9%, the D90% from 41.7% to 49.0%, and the D10% from 222.6% to 182.3%.

Conclusion(s):

This work evaluated the target coverage and hot spots in a simple geometry for different MBRT beam configurations. Compared to conventional treatment dose distributions which generally have V100% and D10% values near 100%, the MBRT delivery techniques had lesser coverage and greater hot spots. In general, increasing the number of fields improves target coverage and decreases the hotspot in the calculated dose distributions. Parallel-opposed fields (2 and 4 beam arrangements) provided minimal improvements due to the overlapping entrance and exit dose. The addition of collimator rotations did improve the metrics evaluated. Based on these results, conventional target coverages are likely not achievable with single isocenter beam arrangements and multi-isocenter or multi-collimator plans need to be evaluated for MBRT dose delivery if attempting to deliver curative dose distributions to a target volume.