Scanning beam-based dose delivery for rotating gamma ray systems for intra- and extra-cranial SRS/SBRT

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INTRODUCTION & AIM

The new generation of rotating gamma ray systems (RGS) is designed for intra- and extra-cranial image-guided SRS/SBRT using 16 focusing ^{60}Co sources arranged on a 35° arc. The traditional spherical shot packing method commonly used in current intracranial radiosurgery is inefficient and sometimes time consuming for large and irregularly shaped targets. This work investigates a scanning beam method dedicated to the new RGS for efficient dose delivery with high dose conformity for intra- and extra-cranial SRS/SBRT.

METHOD

An EGS4/PRESTA user code MCSIM was used for accurate dose calculation for the RGS ^{60}Co beams of different cone sizes. In our method, the tumor volume is divided into layers along the cranial-caudal direction, and the layer thickness and the corresponding cone size are determined based on the tumor axial dimensions. A scanning pattern of a coplanar beam set is developed with the beam edge following the tumor periphery for optimal conformity and dose fall-off. Racetrack-shaped tumors with adjustable lengths are investigated.

RESULTS

Tumors under investigation are of racetrack shape with semicircle radius of 1.2mm, thickness of 1.2mm, and inter-semicircle distance of 1.2, 2.4, and 3.6 mm. Tumor volumes varied from 8.88-15.80cc. Our results from manual forward planning showed that dose could be prescribed to ~50% isodose lines to achieve good target coverage ($V_{100\%RX}$ ~95-95.8%; $V_{90\%RX}$ ~98.6-99.4%) with steep dose fall-off in surrounding normal tissues. Both the conformity index (Paddick CI ~0.49-0.66; RTOG CI ~1.4-1.85) and gradient index (GI ~4.1-4.68) were comparable to static gamma knife systems and dependent on the tumor size.

Table 1 | The volumes, prescription isodoses, PTV coverage, high & intermediate dose spillage of racetrack-shaped tumors (r: semicircle radius, 1.2mm; d: inter-semicircle distance).

	d=r	d=2r	d=3r
Volume	8.88 cc	12.34 cc	15.80 cc
Prescription isodose	52% D_{max}	51.6% D_{max}	48.9% D_{max}
$V_{100\%RX}$	95.8% PTV	95.1% PTV	95.0% PTV
$V_{90\%RX}$	99.0% PTV	99.4% PTV	98.6% PTV
$R_{50\%}$	4.1	4.07	4.68
RTOG CI	1.4	1.37	1.85
Paddick CI	0.65	0.66	0.49

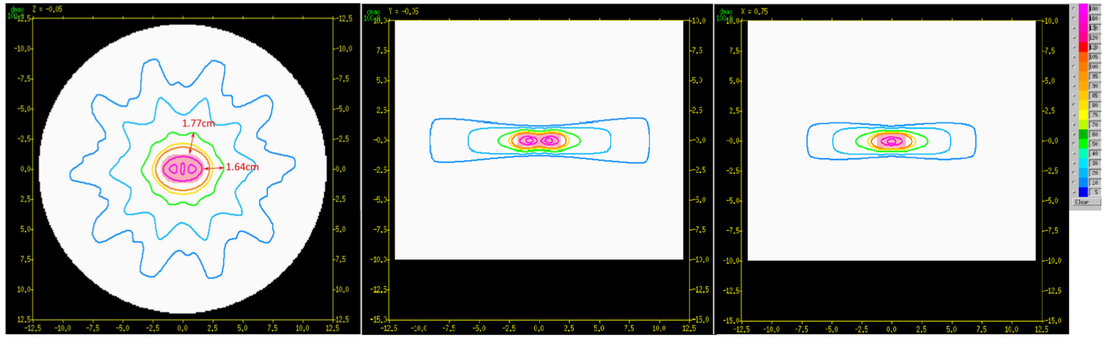

Figure 1 | The axial (left), coronal (middle), and sagittal (right) view of the tumor volume and the isodose lines. The tumor is of racetrack shape with semicircle radius of 1.2mm, thickness of 1.2mm, and inter-semicircle distance of 1.2mm. Beams instead of spherical cones of a cone size of 1.5mm was used for dose painting.

CONCLUSIONS

This study demonstrates the feasibility and great potential of the scanning beam-based dose painting delivery method for the new RGS. Future in-depth investigations will focus on the auto-optimization on beam sizes and weights and also realistic patient plans to quantify the improvement of target dose conformity and delivery efficiency.