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Dosimetric evaluation of static and rotating Gamma ray systems for intracranial SRS/SRT

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INTRODUCTION

A novel designed Rotating gamma ray system (RGS) was developed to deliver an ablative radiation dose to a lesion target while sparing normal tissues without invasive injury. The sharp dose gradient and highly focused radiation beams system was available for clinical applications of both intracranial and extracranial sites (the CybeRay system).

CybeRay system is designed with a treatment head of 16 cobalt-60 sources which are arranged in two parallel rows, with a span of up to 35° in the superior–inferior direction. All the cobalt-60 sources focused to the isocenter with 6 different size collimators as 0.6cm, 0.9cm, 1.2cm, 1.6cm, 2cm, 2.5cm diameter. The irradiation head can rotate 360 degree with a maximum speed of one rotation per minute. The sources can be switched off and on at any angle. The shot can be a full or partial arc. Source to isocenter distance is 60.8 cm. Bore diameter is 60 cm and dose rate is 5 Gy/min.

This report investigated the dosimetric parameters and treatment plan quality of RGS and compare it to Gammaknife system.

AIM

Both static and rotating Gamma-ray delivery systems have been developed and used clinically for intracranial SRS/SRT. This work investigated the dosimetric parameters and treatment plan quality of RGS and compare it to Gammaknife system.

RESULTS

The mean target coverage was 99.8%±0.19, 99.2%±0.85, 99.13±0.84, 98.8±1.45 for MF, MS, IAO, GK, respectively (p>0.05).

The median CI was 0.47, 0.51, 0.48, 0.42 for MF, MS, IAO, GK, respectively (p= 0.98). The difference between mean target dose, minimum and maximum dose was statistically insignificant for these plans.

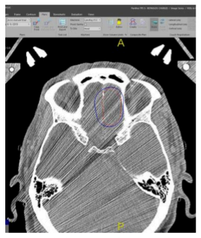
The median GI was 3.52, 3.29, 3.37, 2.73 for MF, MS, IAO, GK, respectively.

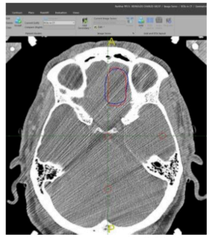
The median number of shots to achieve an acceptable plan was 3, 6, 6, 5 and the mean beam-on time to deliver the plan was 25.5±12.8, 24.3±11.8, 22.2±9.2, 36.9±13.4 minutes for MF, MS, IAO, GK, respectively.

Four cases had optical nerve and brain stem involvement but showed no significant dose difference in the critical structures


Manual Forward


Manual Swing


Inverse Auto Optimization


Gamma-knife

	Volume	Presc	Time minutes				CI				GI(V50%/V100%)				Coverage(%)			
	cc	cGy	M	SW	OPT	GK	M	SW	OPT	GK	M	SW	OPT	GK	Cover M	Cover SW	Cover OPT	Cover GK
case1	7.4	1800	22.7	23	27.9	22.8	1.6	1.9	1.6	1.3	3.2	2.9	3.2	3.1	99.2	98.1	94.6	93.2
case2	0.7	2000	21.8	19.8	16.4	23.2	1.9	1.8	2.1	4	4	3.5	3.7	2.7	100	100	100	100
case3	1.2	2000	14.1	14	13.5	19.1	2.1	1.9	1.8	2.4	3.4	3.2	3.3	2.5	99.4	99.6	100	100
case4	1	2000	12.4	11.8	17.6	18.5	1.5	1.5	1.6	2.9	3.9	3.6	3.6	2.6	99.8	99.5	99.6	100
case5	1.6	1800	34	34.2	29.3	31.3	2.8	2.8	3.1	2.8	3.6	3.3	3.4	3	99.9	99.9	99.6	96.6
case6	5.5	1800	35	35.8	21.5	47.5	1.8	1.7	2.1	2.4	3.3	3.1	3	2.7	100	99.6	99.6	99.3
case7	0.5	1300	10.1	10.5	10.2	29.9	2	1.8	2	1.4	4.2	4	4	3	100	100	99.7	98
case8	3.2	1300	25.5	21.7	21	50.6	2.1	1.9	2	1.7	3.4	3.2	3.4	2.8	100	99.6	99.6	99.7
case9	0.2	1300	16.6	16.4	15	44.2	2.5	2.3	2.5	2.8	4.7	4.5	4.3	2.7	100	100	53	100
case10	1.3	1300	19.4	17.4	18.2	33.4	2.1	2.2	1.9	1.4	3.6	3.6	3.7	2.7	100	95.2	99.4	100
case11	12.3	1800	44.8	41.8	37.3	51.1	1.7	1.5	2.1	2.1	3.2	3.1	3	2.7	99.8	99.3	98.6	99.8
case12	15.5	1800	49.7	44.8	38.6	58.3	2.1	1.9	1.9	2.1	3	2.7	3.1	2.6	99.9	99.6	99.4	99.4

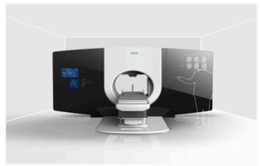
METHOD

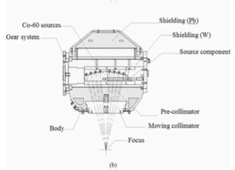
12 patients with brain lesions went through SRS treatment with Gamma-knife at Temple University were involved in this research.

The median target volume is 1.5 cm3 (range 0.5-15.5 cm3), SRS radiation dose prescription for Gamma-knife from 13Gy to 20Gy, medium18Gy, all for single fraction.

All The DICOM-RT based image sets for Gamma-knife were imported to velocity(version 4.1) which is an image process and achieve system provided by Varian. Prowess TPS.

Designed 3 type of RGS plans for each case including: Manual-forward (MF), Manual-forward with swing angle (MS), Inverse-automated optimization (IAO).





CONCLUSIONS

Both Rotating Gamma ray System (RGS) and Gamma-knife delivery systems provide clinically acceptable dose distributions for intracranial SRS/SRT with small differences in target coverage, CI, GI and treatment time. Prowess provided flexible planning options for the new RGS to achieve superior target dose coverage and critical structure sparing.

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