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Optimizing LINAC-Based Stereotactic Radiosurgery Dosimetric Outcomes as Dictated by Beam Energy, Multileaf Collimator Size, and Prescribed Isodose Level

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Abstract

Background and Purpose: Radiation therapy is one of the methods for the treatment of brain tumors. Besides using Co-60-based radiation, LINAC-based stereotactic radiosurgery (SRS) has been widely used in the treatment of intracranial tumors. This study aims to compare the dosimetric outcomes of different SRS methods for typical brain tumors of various sizes, as dictated by beam energy, MLC leaf width, and prescribed isodose level (IDL) using the dynamic conformal arc. **Methods:** Hypothetical target lesions of 4 different sizes were contoured on the brain MRI images of an index patient. The PTVs were constructed to fall within four respective categories (<0.5, 0.5 - 1.0, 1.0 - 4.0, 4.0 - 10.0 cc), in inverse proportion to the prescription dose range of 16 - 22.5 Gy. For each lesion, SRS plans were analyzed independently between: 1) two photon beam energies with different dose rates (6X-FFF with 1400 MU/min vs. 10X-FFF with 2400 MU/min); 2) two MLC leaf widths (0.5 cm vs. 0.25 cm); and 3) two different prescribed isodose lines (90% IDL vs. 80% IDL). The degree of normal tissue sparing was evaluated by the amount of brain volume receiving more than 12 Gy (V_{12}) and the dose Gradient Index (GI), defined as the ratio between the volume receiving more than 50% of the prescribed dose ($V_{50\%}$) and the PTV volume. Tumor dose inhomogeneity was analyzed in relation to the maximum dose (D_{max}) deposited, while conformity was assessed using the Conformity Index (CI), defined as the ratio of the $V_{100\%}$ volume to the PTV volume. Treatment beam-on time was also compared. All three independent variables (beam energy, MLC leaf width, and prescribed

IDL) were held constant, except for the one being analyzed, with mean relative differences in the dosimetric outcomes determined for all four lesions of respective volumes. **Results**: The 4 PTV volumes contoured were: 0.35, 0.68, 1.76, and 5.60 cc, respectively. D_{max} was affected only by the prescribed IDL, while the tumor CI did not exhibit any significant difference for all 3 variables analyzed. Compared to a beam energy of 6X FFF, the 10X FFF plans were found to have a GI and V_{12} that were both increased by about 13% and 14%, respectively. However, the higher beam energy resulted in a shorter beam-on time by approximately 49%. Compared to 0.25 cm MLC leaf-width, the 0.5 cm plans have higher GI by 22.12% ± 8.64%, higher V_{12} by 22.20% ± 11.12%, and shorter beam-on time by 2.63% ± 1.07%. Compared to 80% IDL, the 90% IDL plans have higher GI by 25.73% ± 9.09%, higher V_{12} by 25.27% ± 10.78%, lower D_{max} by 11.02% ± 0.19%, and shorter beam-on time by 12.80% ± 0.78%. This study showed that: 1) lower beam energy plans may provide better brain sparing but incur much longer beam-on time; 2) thinner MLC leaf width may provide better brain sparing at the expense of slightly longer treatment time; and 3) prescribing dose at lower IDL may provide better brain sparing but result in higher tumor dose inhomogeneity and longer beam-on time. **Conclusion:** Beam energy, MLC leaf width, and prescribed IDL may each affect tumor dose coverage, normal brain tissue sparing, or treatment duration. LINAC-based SRS practitioners can select a customized treatment strategy in order to achieve plan goals.

Keywords

SRS, DCA, MLC

1. Introduction

Primary and metastatic brain tumors contribute significantly to the cancer burden in the United States. Primary brain tumors have an incidence of 18.1 per 100,00 persons per year and survival rates at 5 and 10 years of 54% and 45%, respectively [1]. Brain cancer is estimated to be the 10th leading cause of cancer death for both males and females in all age groups [2]. According to the National Brain Tumor Society (NBTS), in 2023, about 94,390 people will receive new primary brain tumor diagnoses, 67,390 of which will be benign, and 59% of which will be in females. An estimated 18,990 people will die because of malignant brain tumors in 2023 [3]. The 5-year relative survival rate for brain and other nervous system cancer is 33.4% (2014-2020), with outcomes varying significantly with age at diagnosis and tumor type. Glioblastoma is the most commonly occurring primary malignant brain tumor as well as the most deadly, with a five-year relative survival rate of only 6.9% and a median survival of only 8 months [4]. Metastatic brain cancer is even prevalent than primary brain tumors, with some models estimating as many as 3 - 400,000 new cases of brain metastases being diagnosed per year in the U.S. As systemic therapies improve, these numbers are expected to continue to rise. Although survival rates for brain metastases are much more challenging to estimate given the heterogeneity in this patient population, based on contemporary data, median survival for all major cancer types ranges from approximately 8 to 16 months, depending on the primary tumor [5].

Radiation therapy is one of the most common treatment options for brain tumors. Standard treatment techniques include whole-brain radiation therapy (WBRT), Volumetric Modulated Arc Therapy (VMAT)/Intensity Modulated Radiation Therapy (IMRT), and Stereotactic radiosurgery (SRS) or fractionated stereotactic radiation therapy (fSRT). As radiation therapy has evolved, multiple clinical trials have been conducted and treatment options have been steadily improved and optimized. All these modalities can play a pivotal role in the treatment of primary brain tumors. For decades, both SRS and WBRT have been the mainstays of therapy for treating brain metastases. WBRT has the benefit of treating both macroscopic and microscopic disease, is commonly used in the setting of multiple brain metastases and has been proven in multiple studies to demonstrate superior outcomes when given after surgical resection and after SRS [6] [7]. Although proven beneficial in multiple clinical scenarios, as both focal and systemic therapies (and thus survival rates) have improved, the toxicities of WBRT have become much more of a focus. Of primary concern has been the well-documented cognitive deterioration/memory loss after WBRT. Multiple recent studies have focused on minimizing this risk using both medications (e.g., memantine) and highly conformal VMAT/IMRT-based WBRT techniques in which the hippocampi are spared. RTOG 0933, for example, showed that WBRT using conformal avoidance of the hippocampi was associated with preservation of both memory and quality of life compared to historical controls [8]. Rather than treating the whole brain, SRS is a highly focused treatment that uses multiple nonparallel beams to deliver high doses to individual targets. Since SRS spares more normal brain tissue, there is a significant decrease in post-treatment neurocognitive decline compared to WBRT, and often improved local control rates. For example, the randomized NCCTG N107C trial concluded that cognitive-deterioration-free survival was more prolonged in patients with brain metastases assigned to SRS (median 3.7 months) compared to those assigned to WBRT (median 3.0 months), $p < 0.0001$. Median overall survival for SRS was 12.2 m vs. 11.6 m ($p = 0.70$) [9].

Over the past few decades, linear accelerator (LINAC)-based stereotactic radiosurgery (SRS) has gained popularity in treating intracranial tumors [10]. With increasing sophistication of treatment technology, multiple parameters in treatment prescription and planning have become available for physicians, physicists and dosimetrists to utilize in order to optimize the dosimetric outcome. Variables such as beam energy, machine characteristics, and prescription isodose level (IDL), can affect the treatment plan with a wide range of tumor coverage, normal tissue sparing, and duration of treatment.

There are multiple published studies focusing on individual parameters in the planning process. For example, Dhabaan *et al.* Monk *et al.* and Chern S *et al.* compared different MLC widths and confirmed dosimetric benefits of narrower leaves for intracranial targets [11]-[13]. Zhao *et al.* explored the impact of prescribing to lower IDLs (50% - 75%) and found improved normal tissue sparing, albeit at the expense of increased target heterogeneity [14]. Similarly, Zhang *et al.* introduced a novel dosimetric metric—Dose Dropping Speed (DDS)—to quantify normal tissue sparing across different IDL prescriptions (50% to 90%) [15]. They showed that lower IDL prescriptions (60% - 70%) yielded steeper dose gradients and better normal tissue protection, whereas higher IDLs such as 90% produced shallower dose fall-off, supporting the clinical preference for lower IDLs when sparing of surrounding brain tissue is a priority. Likewise, Laoui *et al.* compared 6X-FFF and 10X-FFF energies in multitarget intracranial SRS and demonstrated that lower energy beams improve dose fall-off and reduce normal brain dose [16]. Lee *et al.* evaluated LINAC-based SRS via dynamic conformal arcs with high-definition MLCs for multiple targets [17]. While each study provided valuable insight, very few combined these variables within a single, consistent planning system.

The present work aims to fill this gap by evaluating all three parameters—beam energy, MLC width, and prescription IDL—using BrainLab Elements with dynamic conformal arcs (DCA). We have designed a study to offer some clarity about what combination of treatment planning variables might result in an ideal plan with maximum tumor coverage and tissue sparing while identifying possible dosimetric trade-offs such as treatment duration. Specifically, we aimed to compare the dosimetric outcomes of different SRS methods for typical brain tumors of various sizes, as dictated by beam energy, multileaf collimator (MLC) leaf width, and prescribed IDL. One rationale would be to supplement the relatively scanty amount of literature reporting the independent analysis of each parameter while controlling the others, including lesion size and prescribing dosage. Furthermore, while most SRS LINACs have dual photon energies and the choice of IDL for dose prescription remains arbitrary, we compared the effects of two different MLC leaf widths, separately available in most SRS platforms, so that better machine choice could be made for individual patient treatment.

Overall, our goal is to provide actionable, system-specific evidence to guide parameter selection, streamline planning decisions, and support institutional standardization.

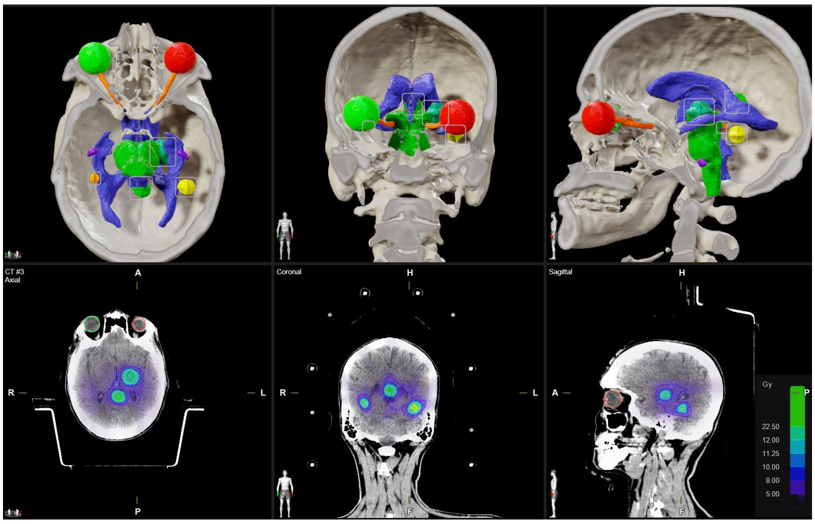
2. Methods

Hypothetical target lesions of 4 different sizes were contoured on brain MRI images of an index patient. The PTVs were constructed to be within 4 respective categories (<0.5, 0.5 - 1.0, 1.0 - 4.0, 4.0 - 10.0 cc). Prescriptions were selected per institutional protocol in inverse proportion to tumor volume, with prescription doses ranging from 16 to 22.5 Gray in a single fraction. Most clinical SRS scenario falls into these four categories. Once the PTV volume exceeds 10.0 cc, fractionated treatment will be involved to reduce the side effects of radiation treatment. Therefore, these four hypotheticals will be used to represent the real SRS treatment. For each lesion, SRS plans were analyzed independently between 1) two photon beam energies with different dose rates (6X-FFF at 1400 MU/min vs. 10X-FFF at 2400 MU/min), 2) two MLC leaf widths (Varian Millennium 0.5 cm vs. Varian HD 0.25 cm), and 3) two different prescribed isodose lines (90% IDL vs. 80% IDL). The beams were planned flattening filter-free (FFF) to increase monitored units (MU) delivered per minute. Treatment was planned on Brainlab Element V2.0 using dynamic conformal arcs, with five pre-programmed couch angles set for all plans, and PTV coverage were kept the same V100% > 95%. Figure 1(a) shows the four mets locations and dose distribution, Figure 1(b) shows the beam setup and MLC shapes, and Figure 1(c) shows the beam setup and dose distribution.

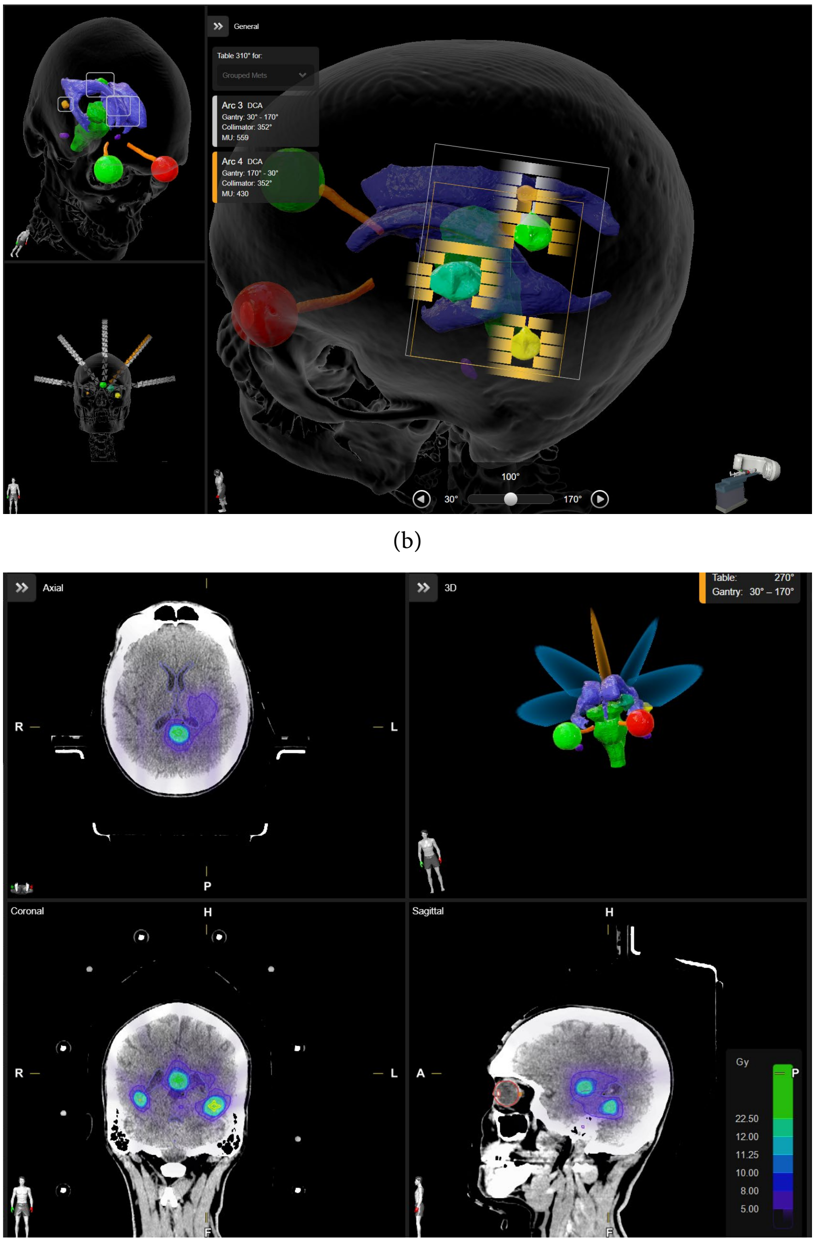
Our measured dosimetric outcomes were selected for possible extrapolation to reflect certain clinical outcomes. The degree of normal tissue sparing was evaluated with the amount of brain volume receiving > 12 Gy (V_{12}) and the dose Gradient Index (GI)—defined as the ratio between volume receiving >50% of prescribed dose ($V_{50\%}$) and PTV volume. Tumor dose inhomogeneity was analyzed with respect to the maximum dose (D_{max}) deposited, while tissue coverage and conformity were assessed via Conformity Index (CI)—defined as the ratio between $V_{100\%}$ and PTV volume. Treatment beam-on time was also compared as a practical measure for real-world settings. All 3 independent variables (beam energy, MLC leaf width, and prescribed IDL) were held constant except the one being analyzed, with mean relative differences of the dosimetric outcomes determined for all 4 lesions of respective volumes. Statistical analysis was performed with Microsoft Excel, including Student's *t*-test for comparison of differences. Plan evaluation uses the following equations:

$$\text{CI} = \frac{\text{Prescription Isodose Volume}}{\text{Target Volume}} \tag{1}$$

$$\text{GI} = \frac{\text{50\% Prescription Isodose Volume}}{\text{Target Volume}} \tag{2}$$



(a)



General

Table 310° for:

Grouped Mets

Arc 3 DCA
Gantry: 30° - 170°
Collimator: 352°
MU: 559

Arc 4 DCA
Gantry: 170° - 30°
Collimator: 352°
MU: 430

Table: 270°
Gantry: 30° – 170°

(b)

(c)

Figure 1. (a) Four mets locations and dose distribution; (b) Four mets SRS plan beam setup and MLC shape display; (c) Four mets SRS plan beam setup and dose distribution.

Table 1 lists the parameters for the plan geometry used in this study.

Table 1. Full plan geometry for the dynamic conformal arcs.

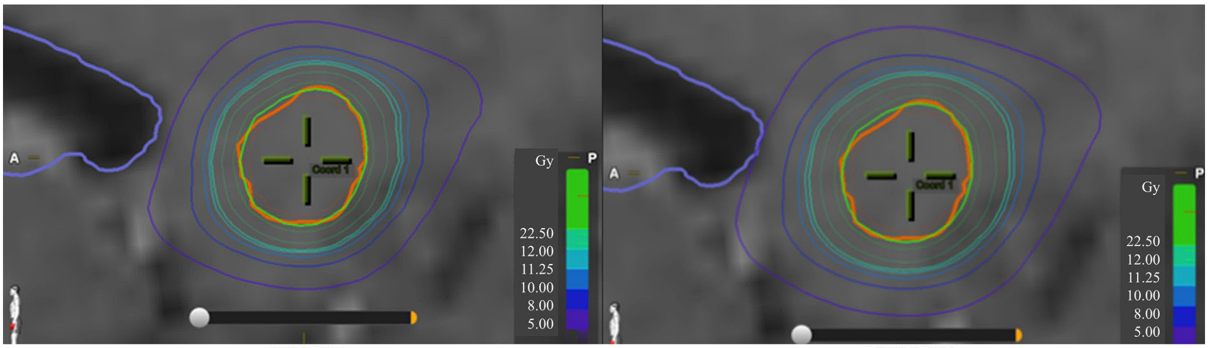
Export ID: Name	Table Angle [˚]	Gantry Start [˚]	Gantry Stop [˚]	Rot. Dir.	Coll. Angle [˚]	X1 [mm]	X2 [mm]	Y1 [mm]	Y2 [mm]	MU per Fraction	Dose Rate [MU/Min]
Arc 1 - DCA											
1: Arc 1	270.0	30.0	170.0	cw	14.0	−22	26	−47	52	1222	1400

Continued

Arc 2 - DCA											
2: Arc 2	270.0	170.0	30.0	ccw	13.0	−35	21	−27	47	593	1400
Arc 3 - DCA											
3: Arc 3	310.0	30.0	170.0	cw	352.0	−36	33	−42	42	559	1400
Arc 4 - DCA											
4: Arc 4	310.0	170.0	30.0	ccw	352.0	−34	25	−42	27	430	1400
Arc 5 - DCA											
5: Arc 5	350.0	30.0	170.0	cw	5.0	−38	36	−32	27	743	1400
Arc 6 - DCA											
6: Arc 6	350.0	170.0	30.0	ccw	5.0	−38	36	−32	17	430	1400
Arc 7 - DCA											
7: Arc 7	10.0	190.0	320.0	cw	5.0	−40	44	−27	22	644	1400
Arc 8 - DCA											
8: Arc 8	10.0	320.0	190.0	ccw	5.0	−31	28	−17	27	430	1400
Arc 9 - DCA											
9: Arc 9	50.0	190.0	330.0	cw	12.0	−33	20	−47	22	747	1400
Arc 10 - DCA											
10: Arc 10	50.0	330.0	190.0	cw	10.0	−32	35	−47	27	808	1400

3. Results

The 4 PTV volumes contoured were measured to be 0.35 cc, 0.68 cc, 1.76 cc, and 5.60 cc. Dosimetric outcomes for each tumor size and combination of variables are available in Appendix (Table A1 shows comparison results for beam energy, Table A2 shows comparison results for MLC type, and Table A3 shows comparison results for isodose level). Dose distribution comparison using 6X-FFF and 10-FFF is illustrated as shown in Figure 2.



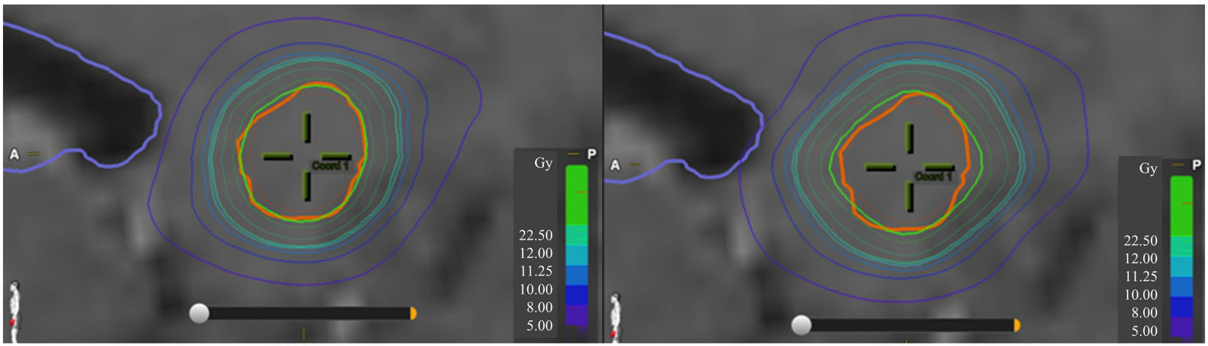
6X-FFF 10X-FFF

Figure 2. Dose distribution over the target using 6X-FFF compared to 10X-FFF.

Tumor CI did not exhibit any significant difference for all 3 variables analyzed. The maximum dose was found to be about 11% higher with the 80% ISL compared to the 90% ISL, but it was not influenced by beam energy or MLC size.

Compared to a beam energy of 6X FFF, the 10X FFF plans (**Figure 2**) were found to have a GI and V_{12} that were both increased about 13% and 14%, respectively (±). However, the higher beam energy resulted in a shorter beam-on time by approximately 49%.

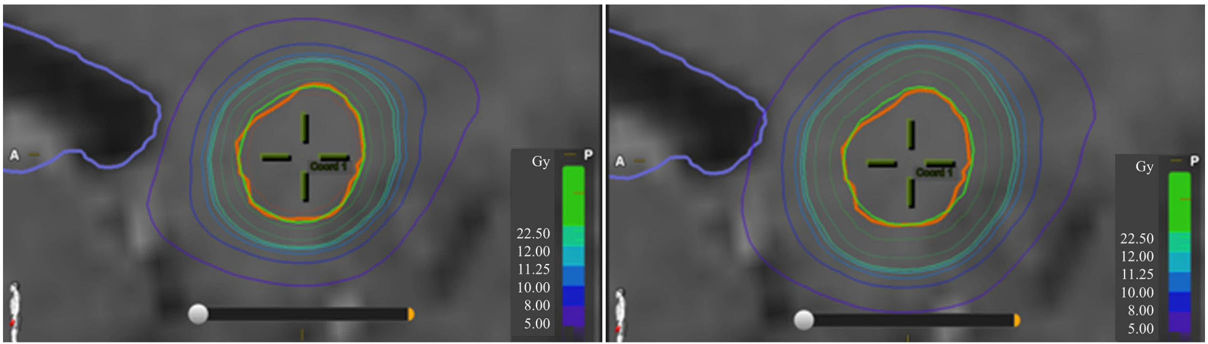
Compared to a 0.25 cm MLC leaf width, the 0.5 cm width of the Varian Millennium led to a 22% increase in GI and V_{12} (**Figure 3**). However, using the wider MLC resulted in a minimal 3% decrease in beam-on time.



0.25 cm 0.5 cm

Figure 3. Dose distribution over target using 0.25 cm multileaf collimator (MLC) width compared to 0.5 cm.

Compared to the treatment target dose being prescribed at the 80% IDL, prescribing at the 90% IDL resulted in a higher GI by 26% and higher V_{12} by 25% (**Figure 4**). However, the 90% IDL plan was also found to have a shorter beam-on time by 13%.



80% IDL 90% IDL

Figure 4. Dose distribution over target using prescription to 80% isodose line (IDL) compared to 90% IDL.

Table 2 summarizes the findings regarding percent differences between the dosimetric outcomes of the variable in question, with other variables held constant.

Table 2. Mean relative differences of dosimetric outcomes as influenced by independent variables of beam energy, multileaf collimator (MLC) width, and prescribed isodose line (IDL).

	10X-FFF vs. 6X-FFF	0.5 cm MLC vs. 0.25 cm MLC	90% IDL vs. 80% IDL
Gradient Index	13.49% ± 7.88%	22.12% ± 8.64%	25.73% ± 9.09%
Conformity Index	NS	NS	NS

Continued

V_{12}	13.52% ± 9.27%	22.20% ± 11.12%	25.27% ± 10.78%
Dmax	NS	NS	−11.02% ± 0.19%
Beam-on time (min)	−49.06% ± 1.16%	−2.63% ± 1.07%	−12.80% ± 0.78%

FFF: flattening free filter, NS: no significant difference (for all four mets volume size with corresponding RX dose from different photon energies, MLC size and IDL selections, CI doesn't show the deviation from each other as dynamic conformal arc plan defined the same PTV RX dose coverage as hard requirements).

4. Discussion

Many pre-planning factors (e.g. tumor size or location, normal tissue anatomy) as well as arbitrary selection of technical set-up factors (e.g. number of beams or arcs, beam directions, beam energy, MLC leaf width, and dose prescription IDL) can influence the quality of SRS dosimetric outcome. This may in term determine the ultimate probability of success in controlling the intracranial tumor while keeping the normal tissue toxicities at acceptably low rates. Paradoxically, as treatment delivery technology advances in time for LINAC-based SRS, more dosimetric choices become available for the planning personnel. Most technical papers for a particular SRS platform are generated based on vendor-supported pre-clinical exploration and quality control testing using artificial phantoms. The actual clinical experiences published for SRS tumor control and toxicity analyses may have been confounded by a wide array of clinical parameters including tumor size, shape and location, prescribed dose, physician preference, dosimetrist skills, etc. We have thus conducted a systemic analysis of dosimetric outcomes based on a consistent human anatomy and controlled for target location, volume & location, aiming to provide quantitative comparisons between two sets of dosimetric parameters: beam energy, MLC leaf width, and dose prescription IDL.

Our results showed that tumor coverage represented by using CI as an optimization objective was not shown to be significantly different between any of the paired parameters for comparison. Instead, the significant differences seen in GI and V_{12} analyses suggest that normal tissue sparing may be a more determining factor in terms of which of the paired parameters should be preferred. Using a lower energy, smaller MLC width, and lower prescription IDL was seen to improve both the GI and V_{12} and may thus be favored especially for cases with heightened concern for treatment induced toxicities. Because of the hypothesized increased risk of brain necrosis with higher dose, we evaluated the Dmax of each plan and showed it to be significantly influenced only by the prescribed IDL. Our data confirmed that prescribing dose at a higher IDL would decrease dose heterogeneity within the target volume. Lastly, as a practical measure, we compared beam-on time and found that the selection of variables to improve tissue sparing would increase the time of treatment.

Previous studies have examined the effects of variables including sharper dose fall-offs of lower beam energies [16] and modest dosimetric advantages of smaller MLC leaf widths [13]. A study by Zhang *et al.* explored the effect of dose prescription at lower IDL that results in sharper dose drop-offs through a novel dosimetric entity named dose-dropping speed [15]. Findings in the dosimetric outcomes may be extrapolated for clinical outcomes such as tumor control and the risk of adverse effects, including radionecrosis [18]. These variables may also affect treatment time, which may then affect positioning accuracy [19] and procedural tolerance for the patient. Other study has also explored the single-isocenter multi-target multi-fraction stereotactic radiotherapy comparing with HyperArc and RapdiArc and found DCA plan can achieve the best dose fall-off [20].

Efforts should continue to explore the best combination of all relevant treatment set-up and planning parameters, primarily with the optimal dosimetric outcome in mind. By exploring the effects of these factors on tumor coverage and normal tissue sparing, it may aid radiation oncology practitioners and planning dosimetrists or physicists to derive the best treatment regimen for their patients. We recognize that a possible improvement seen in dosimetric outcome may not necessarily translate into a clinically significant benefit. This is largely due to our intent to ensure set-up consistency with each controlled parameter (*i.e.* tumor volume, dose, beam energy, MLC leaf width, and dose prescribing IDL) and avoid confounding variables that may exist in a heterogeneous patient cohort. For example, we drew our hypothetical PTV largely within the cerebral cortex and did not consider the influence of nearby critical structures such as brainstem, skull base, or optic pathway. We also avoided more complicated yet realistic technical and clinical factors, such as radiation beam angles or field/arc arrangement (e.g. trans-axial, noncoplanar, static fields, dynamic arc), tumor shape (spheroid vs. irregular/elongated), tumor type/histology, patient comorbidity, etc.

Despite the possibly predictable demonstration of these dosimetric principles under an idealized situation, our findings may be helpful for the initial selection of treatment planning parameters. They may also assist in sustaining operational efficiency when faced with other extraneous factors such as clinic patient volume, patient endurance during treatment, and machine availability. Once the treatment team decides which outcome to prioritize for each individual patient, it may be helpful to use our study's findings as a starting point to generate and revise an appropriate treatment plan.

By quantifying dosimetric outcomes, it may be feasible for one to extrapolate onto perceived clinical benefits by adjusting the variables. Future directions could include correlating actual clinical outcomes with these dosimetric outcome predictions through prospective clinical trials.

Although this study only discusses one single case with four hypothetical target volumes. It covers most of clinical SRS scenarios as SRS tumor volumes fall within 10.0 cc limit. These four categories represented the different RX doses to corresponding tumor volumes.

5. Conclusion

This study showed that for LINAC-based SRS: 1) lower beam energy plans may provide better brain sparing but incur much longer beam-on time, 2) thinner MLC leaf width may provide better brain sparing at the expense of slightly longer treatment time, and 3) prescribing dose at lower IDL may provide better brain sparing but result in higher tumor dose inhomogeneity and longer beam-on time. It may thus provide useful information for LINAC-based SRS practitioners to better formulate customized treatment strategy based on how beam energy, MLC leaf width, and prescribed IDL may each affect tumor dose coverage, normal brain tissue sparing or treatment duration.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

Table A1. Beam Energy 6X FFF vs. 10X FFF.

PTV(cc)	Rx (Gy)	MLC size (cm)	ISD %	GI 6X	GI 10X	V_{12} 6X	V_{12} 10X	TX min 6X	TX min 10X
0.35	22.5	0.5	90%	8.38	8.85	2.57	2.75	2.88	1.48
0.35	22.5	0.5	80%	6.08	6.52	1.81	2.09	3.3	1.72
0.35	22.5	0.25	90%	5.87	7.73	1.77	2.36	2.96	1.54
0.35	22.5	0.25	80%	5.1	5.33	1.65	1.7	3.37	1.79
0.68	20	0.5	90%	5.8	6.89	3.12	3.63	2.53	1.28
0.68	20	0.5	80%	5.01	5.32	2.65	2.79	2.88	1.48
0.68	20	0.25	90%	4.71	5.5	2.39	3.05	2.58	1.33
0.68	20	0.25	80%	3.76	4.21	1.95	2.17	2.95	1.55
1.76	18	0.5	90%	4.63	5.17	5.63	6.01	2.22	1.11
1.76	18	0.5	80%	4	4.23	4.51	5.22	2.53	1.27
1.76	18	0.25	90%	3.75	4.38	4.25	5.24	2.26	1.14
1.76	18	0.25	80%	3.02	3.65	3.59	3.96	2.58	1.32
5.6	16	0.5	90%	3.62	4.15	11.47	13.26	1.91	0.94
5.6	16	0.5	80%	2.97	3.3	9.97	10.21	2.17	1.07
5.6	16	0.25	90%	3.02	3.79	10.01	12.07	1.93	0.96
5.6	16	0.25	80%	2.66	2.84	9.16	9.37	2.19	1.1

Table A2. MLC size Millennium (M): 0.5 cm vs. HD (H): 0.25 cm.

PTV (cc)	Rx (Gy)	%IDL	Energy	GI M	GI H	V_{12}-M	V_{12}-H	TX min M	TX min H
0.35	22.5	90%	6X	8.38	5.87	2.57	1.77	2.88	2.96
0.35	22.5	80%	6X	6.08	5.1	1.81	1.65	3.3	3.37
0.35	22.5	90%	10X	8.85	7.73	2.75	2.36	1.48	1.54
0.35	22.5	80%	10X	6.52	5.33	2.09	1.7	1.72	1.79
0.68	20	90%	6X	5.8	4.71	3.12	2.39	2.53	2.58
0.68	20	80%	6X	5.01	3.76	2.65	1.95	2.88	2.95
0.68	20	90%	10X	6.89	5.5	3.63	3.05	1.28	1.33
0.68	20	80%	10X	5.32	4.21	2.79	2.17	1.48	1.55
1.76	18	90%	6X	4.63	3.75	5.63	4.25	2.22	2.26
1.76	18	80%	6X	4	3.02	4.51	3.59	2.53	2.58
1.76	18	90%	10X	5.17	4.38	6.01	5.24	1.11	1.14
1.76	18	80%	10X	4.23	3.65	5.22	3.96	1.27	1.32
5.6	16	90%	6X	3.62	3.02	11.47	10.01	1.91	1.93
5.6	16	80%	6X	2.97	2.66	9.97	9.16	2.17	2.19
5.6	16	90%	10X	4.15	3.79	13.26	12.07	0.94	0.96
5.6	16	80%	10X	3.3	2.84	10.21	9.37	1.07	1.1

Table A3. IDL 90% vs. 80%.

PTV (cc)	Rx (Gy)	MLC (cm)	Energy	GI 90%	GI 80%	V_{12}-90%	V_{12}-80%	TX min 90%	TX min 80%
0.35	22.5	0.5	6X	8.38	6.08	2.57	1.81	2.88	3.3
0.35	22.5	0.25	6X	5.87	5.1	1.77	1.65	2.96	3.37
0.35	22.5	0.5	10X	8.85	6.52	2.75	2.09	1.48	1.72
0.35	22.5	0.25	10X	7.73	5.33	2.36	1.7	1.54	1.79
0.68	20	0.5	6X	5.8	5.01	3.12	2.65	2.53	2.88
0.68	20	0.25	6X	4.71	3.76	2.39	1.95	2.58	2.95
0.68	20	0.5	10X	6.89	5.32	3.63	2.79	1.28	1.48
0.68	20	0.25	10X	5.5	4.21	3.05	2.17	1.33	1.55
1.76	18	0.5	6X	4.63	4	5.63	4.51	2.22	2.53
1.76	18	0.25	6X	3.75	3.02	4.25	3.59	2.26	2.58
1.76	18	0.5	10X	5.17	4.23	6.01	5.22	1.11	1.27
1.76	18	0.25	10X	4.38	3.65	5.24	3.96	1.14	1.32
5.6	16	0.5	6X	3.62	2.97	11.47	9.97	1.91	2.17
5.6	16	0.25	6X	3.02	2.66	10.01	9.16	1.93	2.19
5.6	16	0.5	10X	4.15	3.3	13.26	10.21	0.94	1.07
5.6	16	0.25	10X	3.79	2.84	12.07	9.37	0.96	1.1