Dosimetric Evaluation between Varian's Eclipse SRS HyperArc and Elekta's Leksell GammaPlan

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ABSTRACT

Purpose: To evaluate stereotactic radiosurgery (SRS) plans for Varian's Eclipse Hyper Arc on TrueBeam Edge and Elekta's Leksell GammaPlan (LGP) on Perfexion.

Methods: Cubic phantom containing five 1cm diameter spheres was imaged using Philips Big Bore CT Simulator while contouring five spheres as tumors and OAR structure for the brainstem. CT/structures were sent to LGP and Eclipse for planning using equivalent prescriptions. LGP's dose optimization balanced low dose and beam-on time to achieve conformity index (CI) = 1.0, Paddick CI (PCI) = 1.0, and gradient index (GI) < 3.0. Similarly, Eclipse incorporated SRS HyperArc technique for automatic isocenter calculation, although collimator angles were manually entered to position targets within Edge's HD MLCs; optimization utilized the SRS normal tissue objective (NTO) to promote steep dose gradients with higher prescription target coverage. Target quality metrics and DVH indices were compared.

Results: LGP and Hyper Arc's V90% and V95% are identical for all targets, while V100% has maximum difference of 0.3%. LGP's V105%, D98%, D95%, D50%, and mean dose exceed HyperArc's with averages of 2.1%, 15cGy, 33cGy, 113cGy, and 82cGy, respectively, indicating increased target dose escalation for LGP. Notably, PCI maximum difference was only 0.04, but LGP's CI and GI were closer to 1.0 and 3.0, respectively; CI and GI had lower averages of 0.09 and 0.73, respectively, demonstrating LGP's dose conformality and sharp dose gradients. Furthermore, LGP also demonstrates greater conformality at low doses as evidenced by smaller average distance to 50% isodose (2.7mm for LGP versus 3.5mm for HyperArc); however, HyperArc minimizes dose bridging between adjacent targets with this effect occurring at 500cGy compared to 700cGy for LGP.

Conclusion: Although LGP offers higher target doses with superior dose fall-off, SRS HyperArc provides comparable plan quality with nearly equivalent PCI while improving patient comfort with reduced treatment times (~6min versus ~115min) and frameless immobilization.

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INTRODUCTION

- SRS and SRT treat intracranial lesions using a stereotactic apparatus with radiation beams
  - **SRS**: stereotactic radiosurgery; **single fraction**
  - **SRT**: stereotactic radiotherapy; **multi-fraction**
- **SRS/SRT** delivers a lethal dose to the target while sparing surrounding normal tissue
  - ➢ **Tight target margins**
  - ➢ **Steep dose gradients**
- Treatment of benign tumors, malignant tumors, and functional disorders.
- Treatment techniques include:
  - Megavoltage x-rays from linacs
  - γ-rays from ^{60}Co sources
  - Heavy charged particles from cyclotrons
- **Linac-based treatment**:
  - Multiple, non-coplanar arcs
  - Shorter treatment time with fewer isocenters
  - Lower hot spot achievable
  - Larger penumbra for MLC-based delivery
- **γ-knife treatment**:
  - "Sphere packing" planning to conform dose to the target due to fixed circular collimation
  - Sharpest dose falloff from target
  - Complex target shape increases delivery time and increases dose heterogeneity

➢ **To evaluate the treatment planning performance of Varian's Eclipse SRS HyperArc with TrueBeam Edge versus Elekta's Leksell GammaPlan on Perfexion**

METHODS AND MATERIALS

- TrueBeam Edge for linac-based planning
  - 6 MV – FFF beam with 6 DOF couch movement
  - HD MLCs: 32 central leaves with 2.5mm width
  - Encompass mask and couch immobilization
- Elekta Perfexion for γ-knife treatment
  - 192 ^{60}Co sources housed in 5 cylindrical rings
  - 12cm thick tungsten collimator with 8 sectors
  - 3 collimator sizes: 4mm, 8mm and 16mm
- Target quality metrics for plan evaluation
  - Conformity index (CI)
    - $CI = Vol.Rx\ isodose / Vol.PTV$
  - Paddick conformity index (PCI)
    - $PCI = \frac{(Overlap\ vol.Rx\ isodose\ \&\ vol.PTV)^2}{Vol.Rx\ isodose \times Vol.PTV}$
  - Gradient index (GI)
    - $GI = Vol.50\%\ isodose / Vol.100\%\ isodose$
- VisionRT's Cube Calibration phantom (Figure 1)
  - Five 1cm diameter spheres representing tumors
  - Brainstem contour added as OAR

➢ **Compare DVH indices, plan parameters, and target quality metrics**

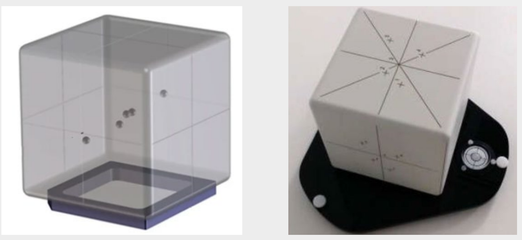

Figure 1. VisionRT's Cube Calibration phantom used for planning.

RESULTS

- Table 1 shows Rx summary for Elekta's Leksell GammaPlan (LGP) versus Eclipse SRS HyperARC (HA)
- Table 2 lists LGP's shot summary for Elekta's Perfexion
- Table 3 lists HA's TrueBeam Edge plan parameters
- Figure 2 and Table 4 provide DVH details for the five tumors and brainstem from LGP and HA

Table 1. Rx's for Elekta's Leksell GammaPlan and Varian's Eclipse SRS HyperArc.

Target	Leksell GammaPlan		Eclipse SRS HyperArc		
	Rx	100% (Gy)	Dose / Fx (Gy)	# Fx	Tx Percentage (%)
Tumor 1	20.0 Gy @ 66%	30.3	20.00	1	100.00
Tumor 2	20.0 Gy @ 65%	30.8	20.00	1	100.00
Tumor 3	18.0 Gy @ 65%	27.7	18.00	1	100.00
Tumor 4	18.0 Gy @ 65%	27.7	18.00	1	100.00
Tumor 5	16.0 Gy @ 64%	25.0	16.00	1	100.00

Table 2. Elekta's Leksell GammaPlan shot summary for Perfexion.

Target	Shots	Gamma angle (°)	Weight	Collimators (4 mm, 8 mm, 16 mm, or Block)								Tx Time (min.)
Tumor 1	1	90	18.80	8	8	8	8	8	8	8	8	16.19
	2	90	7.36	8	8	8	8	B	8	8	8	7.29
	3	90	0.59	8	8	8	8	4	8	8	8	0.51
	4	90	1.52	8	4	8	8	8	8	8	8	1.32
Tumor 2	1	90	14.53	8	8	8	8	8	8	8	8	12.37
	2	90	13.92	8	8	8	8	8	4	8	8	11.96
	3	90	1.31	8	8	8	8	8	4	4	8	1.14
Tumor 3	1	90	23.09	8	8	8	8	8	8	8	8	19.00
	2	90	1.57	8	4	8	8	8	8	8	8	1.31
	3	90	1.76	4	4	8	8	4	8	8	8	1.50
Tumor 4	1	90	7.99	8	8	8	8	8	8	8	8	6.79
	2	90	11.65	8	8	8	8	8	8	B	8	11.54
	3	90	3.36	8	8	8	8	8	8	4	8	2.87
	4	90	1.31	8	8	8	8	8	8	4	8	1.13
	5	90	1.21	8	8	8	8	8	8	4	8	1.04
Tumor 5	1	90	23.77	8	8	8	8	8	8	8	8	18.63
Total	**16**	—	—	—	—	—	—	—	—	—	—	**114.59**

Table 3. Varian's Eclipse SRS HyperArc treatment plan parameters for TrueBeam Edge.

Field	Energy	Dose Rate (MU/min)	MLC	Field Weight	Gantry Rotation (°)	Collimator Rotation (°)	Couch Rotation (°)	MU	Time (min.)
CW T0	6X-FFF	1400	VMAT	1.316	180.1 CW 179.9	20.0	0.0	2532	1.81
CCW T315	6X-FFF	1400	VMAT	0.929	179.9 CCW 0.0	50.0	315.0	1787	1.28
CCW T45	6X-FFF	1400	VMAT	0.870	0.0 CCW 180.1	80.0	45.0	1673	1.20
CW T90	6X-FFF	1400	VMAT	1.104	180.1 CW 0.0	355.0	90.0	2122	1.52
Total	—	—	—	—	—	—	—	**8114**	**5.80**

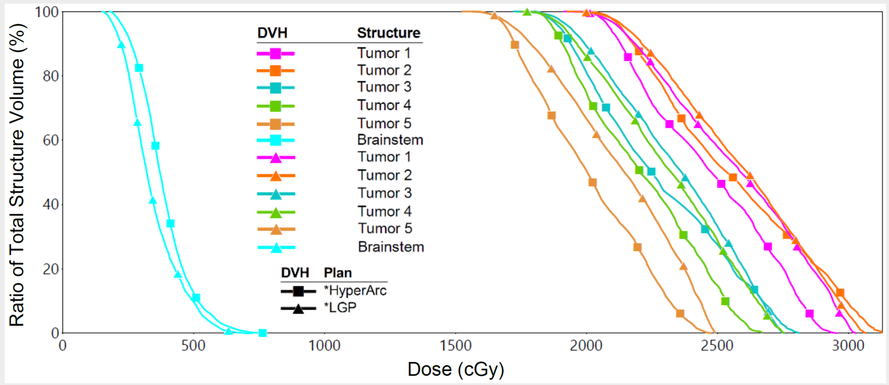

Figure 2. Dose-volume histogram (DVH) for five tumors and brainstem from Varian's Eclipse SRS HyperArc and Elekta's Leksell GammaPlan (LGP).

Table 4. Elekta's Leksell GammaPlan (LGP) and Varian's Eclipse SRS HyperArc (HA) dose-volume histogram (DVH) indices and target quality metrics.

Structure	V105% (%)		V100% (%)		V95% (%)		V90% (%)		D98% (cGy)		D95% (cGy)		D50% (cGy)		D2% (cGy)		D1% (cGy)		Min (cGy)		Max (cGy)		Mean (cGy)		CI		PCI		GI		Distance from target to 50% isodose (cm)	
	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA	LGP	HA
Tumor 1	96.6	93.4	99.7	99.9	100	100	100	100	2067	2053	2125	2087	2588	2476	3001	2889	3010	2907	1913	1944	3028	2958	2572	2471	1.03	1.11	0.88	0.84	3.15	3.65	0.29	0.30
Tumor 2	97.7	97.5	99.7	100	100	100	100	100	2092	2092	2148	2132	2613	2535	3036	3085	3046	3101	1923	1989	3067	3128	2596	2563	1.00	1.15	0.86	0.82	3.09	3.78	0.26	0.34
Tumor 3	97.8	95.6	99.8	100	100	100	100	100	1885	1854	1936	1898	2362	2246	2728	2762	2737	2781	1720	1793	2757	2812	2343	2280	1.06	1.15	0.86	0.83	2.95	3.90	0.24	0.42
Tumor 4	96.6	92.7	99.8	99.7	100	100	100	100	1864	1844	1913	1871	2322	2204	2723	2617	2740	2631	1749	1732	2754	2667	2313	2212	1.03	1.13	0.81	0.83	3.29	3.69	0.32	0.32
Tumor 5	97.4	96.4	99.7	99.8	100	100	100	100	1669	1659	1722	1693	2144	2002	2476	2413	2484	2434	1524	1564	2490	2476	2125	2012	1.08	1.12	0.86	0.84	2.85	3.97	0.23	0.38
Brainstem	0	0.0	0	0	0	0	0	0	178	207	198	232	321	371	592	636	612	671	149	177	727	780	340	382	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

DISCUSSION

- **Trends from data** between Leksell GammaPlan (LGP) and SRS HyperArc (HA):
  - V90% and V95% are identical for targets
  - V100% maximum difference = 0.3%
  - V105%, D98%, D95%, D50%, and mean dose for LGP exceed values from HA
  - PCI maximum difference = 0.04
  - LGP's CI and GI are closer to 1.0 and 3.0, respectively
- **LGP exhibits increased dose conformality and sharper dose gradients** indicated by target quality metrics
- **LGP provides enhanced conformality at low doses**
  - Shorter average distance to 50% isodose line
    - LGP: 2.7mm
    - HA: 3.5mm
- **HA minimizes dose bridging** between adjacent targets
  - LGP: 700cGy isodose
  - HA: 500cGy

CONCLUSIONS

- **Leksell GammaPlan advantages** versus SRS HyperArc:
  - Higher target doses
  - Steeper dose fall-off
- **SRS HyperArc advantages** versus Leksell GammaPlan:
  - Similar PCI index as γ-knife treatment
  - Improved patient comfort with shorter Tx time

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