Stereotactic radiosurgery in Tomotherapy

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Stereotactic radiosurgery

AAPM REPORT NO. 54

STEREOTACTIC RADIOSURGERY

Report of Task Group 42
Radiation Therapy Committee

Michael C. Schell (Chairman)
Frank J. Bova
David A. Larson (Consultant)
Dennis D. Leavitt
Wendell R. Lutz
Ervin B. Podgorsak
Andrew Wu

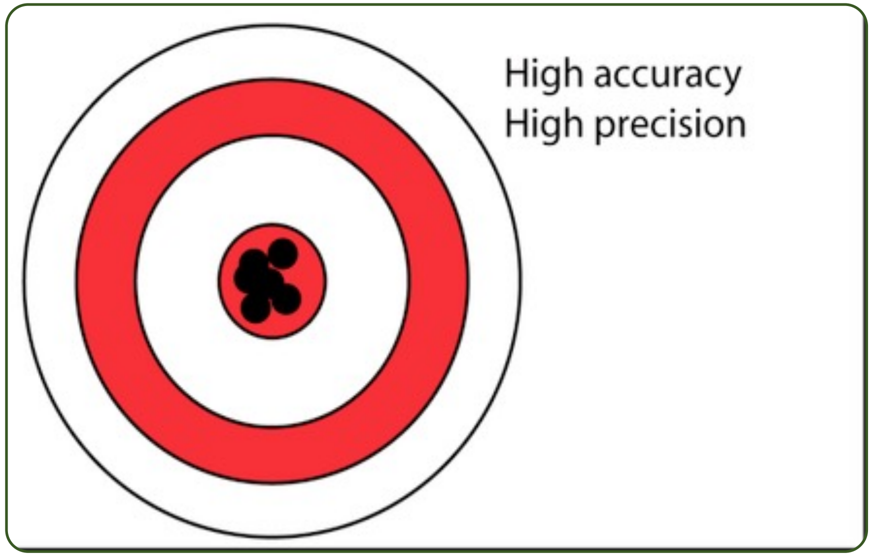
Major requirements

sisting of: (1) accurately defining the shape and location of the lesion and the neuroanatomy in the reference frame of a stereotactic frame system with CT, MRI or angiography; and (2) developing and delivering the planned

CT, MRI or angiography; and (2) developing and delivering the planned treatment. The treatment techniques produce a concentrated dose in the lesion with steep dose gradients external to the treatment volume. The rapid dose falloff from the edge of the treatment volume provides dramatic sparing of normal brain tissues.

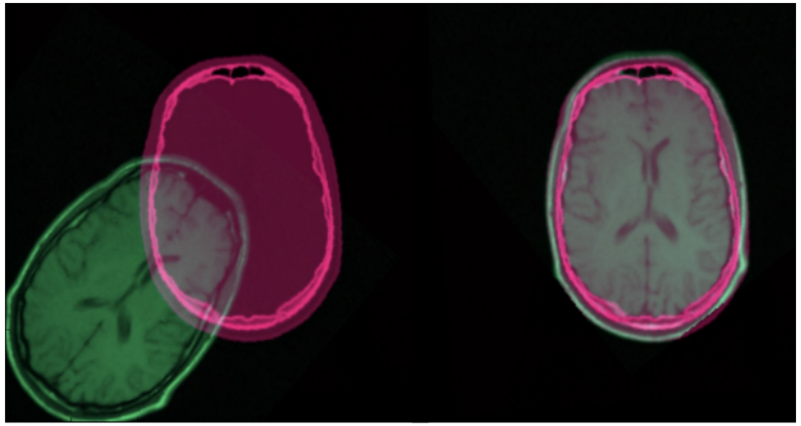
Stereotactic radiosurgery requirements

fractions of treatments. SRS and SRT are essentially two-step processes consisting of: (1) accurately defining the shape and location of the lesion and the neuroanatomy in the reference frame of a stereotactic frame system with CT, MRI or angiography; and (2) developing and delivering the planned treatment. The treatment techniques produce a concentrated dose in the le-



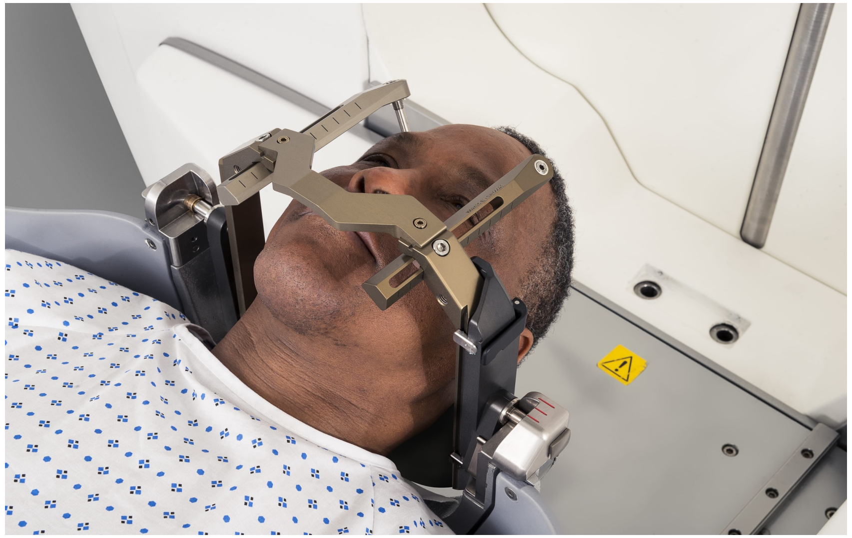
Immobilization system

Multiple image modalities and image registration

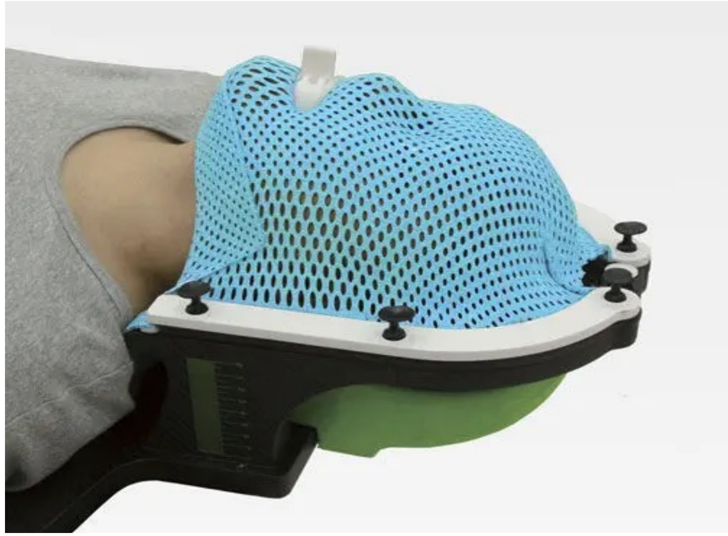


1st requirement of SRS

Immobilization system



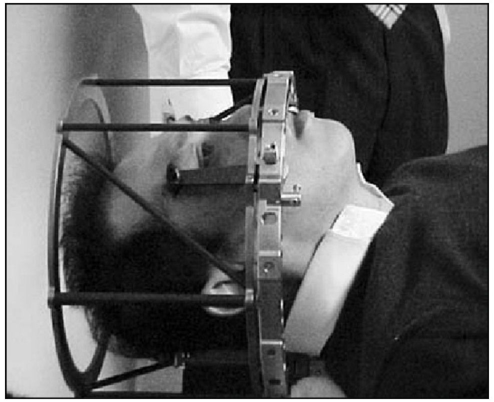
Invasive system



Non-invasive system

1st requirement of SRS

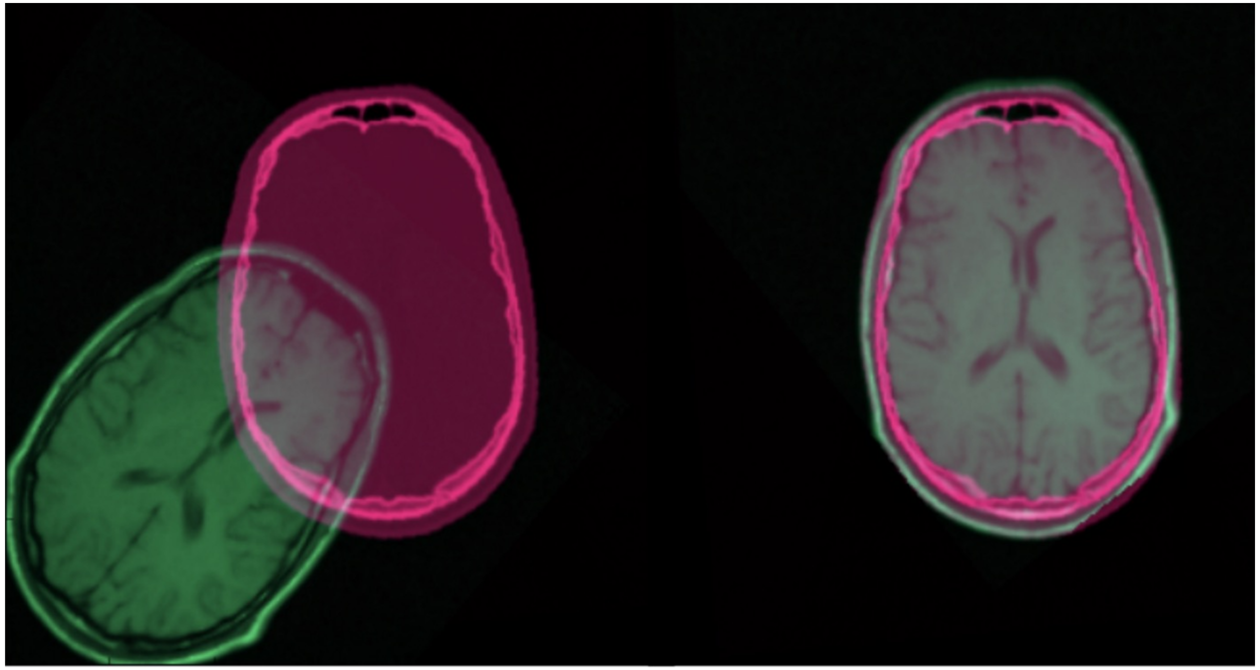
Stereotactic frame system with CT, MRI or angiography



Brown-Robert-Well (BRW)

BrainLab® System

Image registration and Organ delineation



1st requirement of SRS

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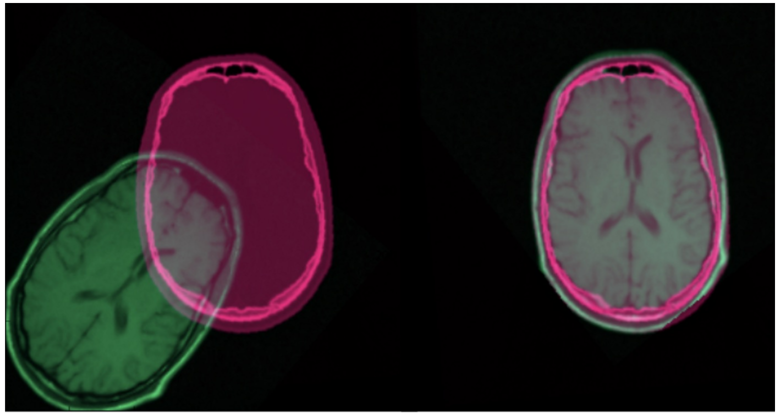
Stereotactic frame system with CT, MRI or angiography

Image registration and Organ delineation



Stereotactic frameless

Frameless Stereotactic Radiosurgery With Linear Accelerator (LINAC)-Based Technology for Brain Metastases: Outcomes Analysis in 141 Patients

Aisin Ibrahim [1], Bernard Fortin [2], Alexis Bujold [2], Nader Kaouam [2], Alma Sylvestre [2], Christian Boukaram [2]

1. Department of Diagnostic Radiology, McGill University, Montréal, CAN 2. Department of Radiation Oncology, Maisonneuve-Rosemont Hospital, Université de Montréal, Montréal, CAN

Corresponding author: Aisin Ibrahim, aisin.ibrahim.med@ssss.gouv.qc.ca

CLINICAL STUDIES

CyberKnife Frameless Stereotactic Radiosurgery for Spinal Lesions: Clinical Experience in 125 Cases

Gerszten, Peter C. M.D., M.P.H.; Ozhasoglu, Cihat Ph.D.; Burton, Steven A. M.D.; Vogel, William J. R.T.; Atkins, Barbara A. R.N.; Kalnicki, Shalom M.D.; Welch, William C. M.D.

Author Information

Stereotactic radiosurgery requirements

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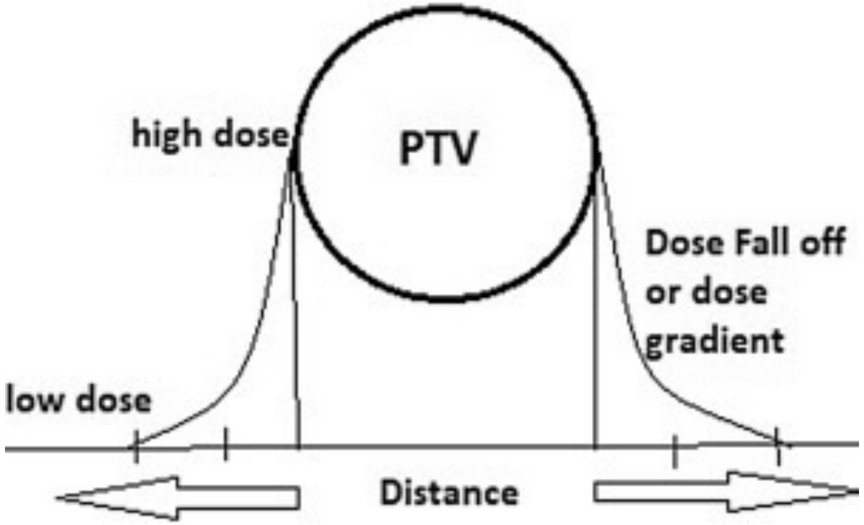
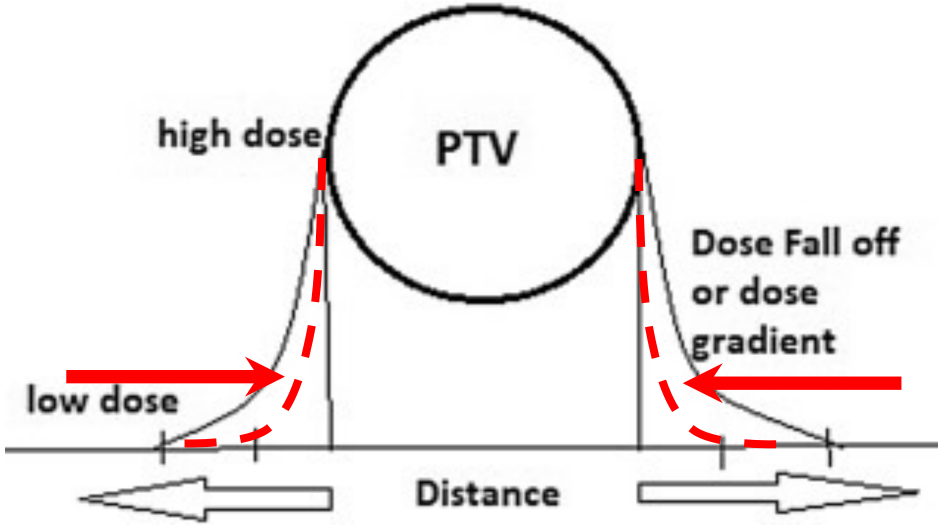


—— Dose gradient for trypical IMRT techniques

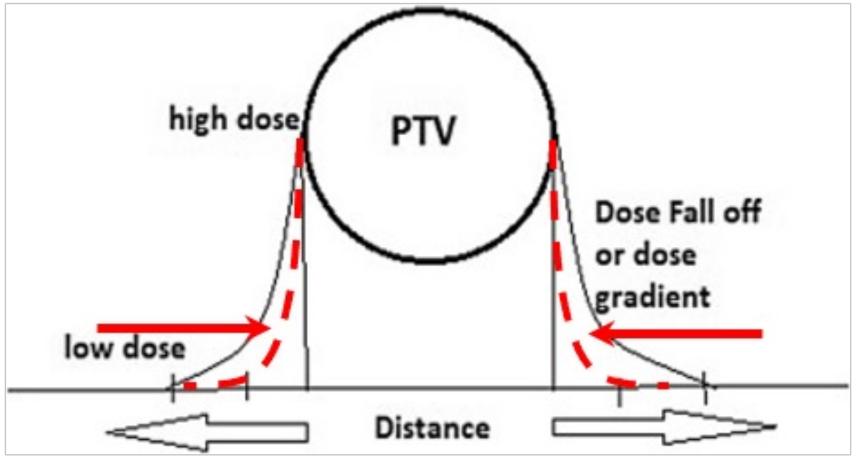


- - - Dose gradient for SRS

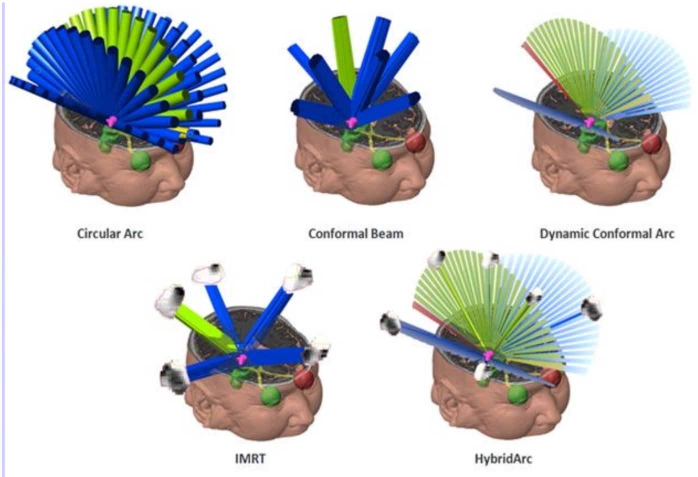
2nd requirement of SRS

Steep dose gradients external to the lesion.

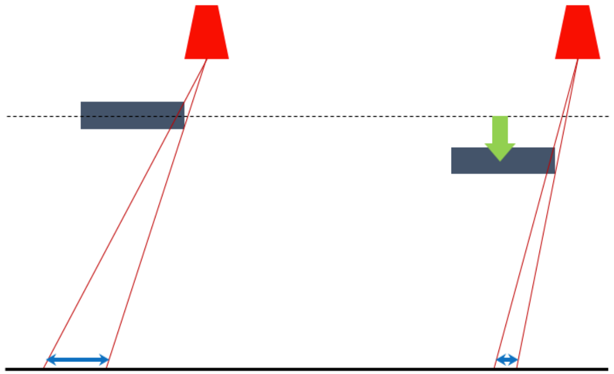
Steep dose gradient/Rapid dose fall off



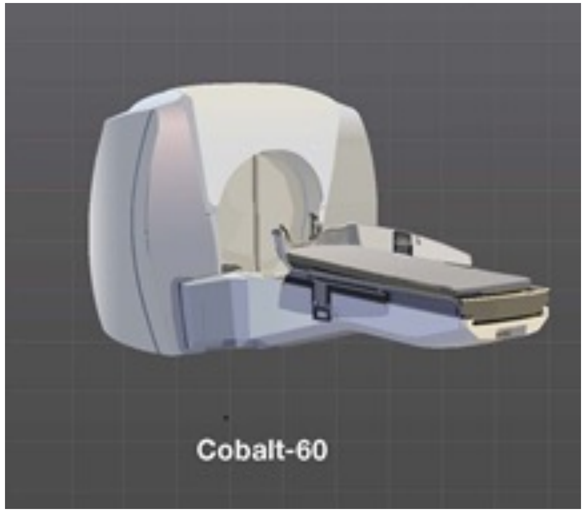
Non-coplanar treatment technique



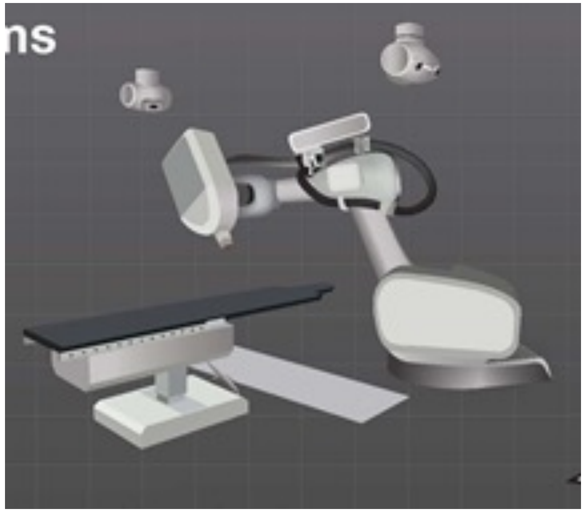
Aperture to axis distance



Treatment modalities in SRS



Gamma Knife®



CyberKnife®

C-arm based Linac
(ceiling-floor mount IGRT)

C-arm based Linac
(CBCT IGRT)

SRS in Tomotherapy

Tomtotherapy

- Binary multi-leaf collimator
- Provides Intensity Modulated RT
- SAD 85 cm
- Image guided RT
  - MVCT (Ctrue®)
  - kVCT (ClearRT®)
- Stereotactic frameless technique

Consideration of treatment plane in SRS

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Treatment planar

Non-coplanar tx tech.
Coplanar tx tech.

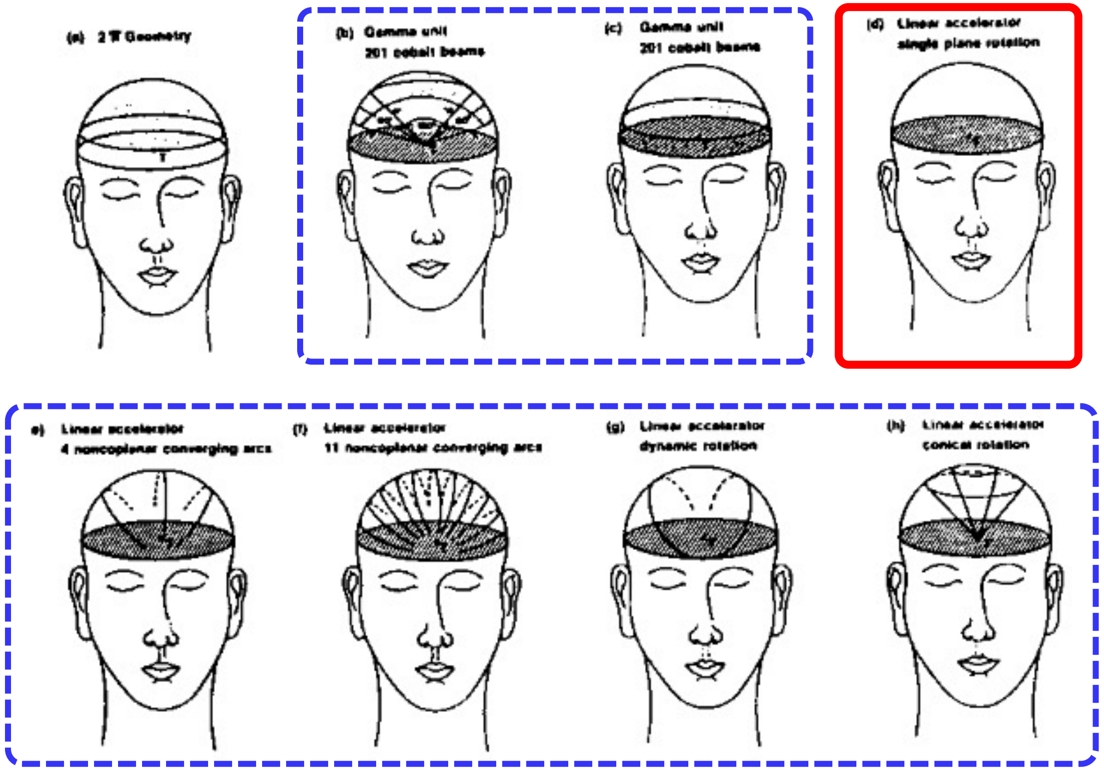

FIGURE 2. Beam-entry patterns on a patient's skull for various radiosurgical techniques. (Podgorsak, E.B. Physics for radiosurgery with linear accelerators, in "Stereotactic Radiosurgery", Chapter 2, pp. 9–34, Neurosurgery Clinics of North America, Vol. 3, edited by D. Lunsford, W.B. Saunders Company, Philadelphia, PA, 1992.)

SRS treatment planning in Tomotherapy

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ELSEVIER

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doi:10.1016/j.meddos.2009.11.003

A TECHNIQUE FOR STEREOTACTIC RADIOSURGERY TREATMENT PLANNING WITH HELICAL TOMOTHERAPY

Emilie T. Soisson, Ph.D., Peter W. Hoban, Ph.D., Thomas Kammeyer, Ph.D., Jeffrey M. Kapatoes, Ph.D., David C. Westerly, Ph.D., Amar Basavatia, M.S., and Wolfgang A. Tomé, Ph.D.

Departments of Human Oncology and Medical Physics, University of Wisconsin School of Medicine and Public Health; and TomoTherapy Inc., Madison, WI

(*Received* 5 *June* 2009; *accepted* 24 *November* 2009)

Abstract—The purpose of this study was to develop an efficient and effective planning technique for stereotactic radiosurgery using helical tomotherapy. Planning CTs and contours of 20 patients, previously treated in our clinic for brain metastases with linac-based radiosurgery using circular collimators, were used to develop a robust TomoTherapy planning technique. Plan calculation times as well as delivery times were recorded for all patients to allow for an efficiency evaluation. In addition, conformation and homogeneity indices were calculated as metrics to compare plan quality with that which is achieved with conventional radiosurgery delivery systems. A robust and efficient planning technique was identified to produce plans of radiosurgical quality using the TomoTherapy treatment planning system. Dose calculation did not exceed a few hours and resulting delivery times were less than 1 hour, which allows the process to fit into a single day radiosurgery workflow. Plan conformity compared favorably with published results for gamma knife radiosurgery. In addition, plan homogeneity was similar to linac-based approaches. The TomoTherapy planning software can be used to create plans of acceptable quality for stereotactic radiosurgery in a time that is appropriate for a radiosurgery workflow that requires that planning and delivery occur within 1 treatment day. © 2011 American Association of Medical Dosimetrists.

Key Words: Stereotactic radiosurgery, Tomotherapy, Brain metastases, Treatment planning.

doi:10.1016/j.meddos.2009.11.003

SRS treatment planning in Tomotherapy

A TECHNIQUE FOR STEREOTACTIC RADIOSURGERY TREATMENT PLANNING WITH HELICAL TOMOTHERAPY

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Departments of Human Oncology and Medical Physics, University of Wisconsin School of Medicine and Public Health; and TomoTherapy Inc., Madison, WI

Plan Objective and Optimization

Through iteration, it was determined that the planning objectives shown in **Tables IIIa** and **IIIb** reliably yield inhomogeneous dose distributions for small (< 2 ml) and large (> 2 ml) targets, respectively. The aim is to “weight” the minimum dose to the target and the maximum dose to the surrounding 3mm ring structure higher than all other target goals so that the prescription isodose coincides with the target boundary. The maximum dose to the *target* is set to the maximum allowed (120Gy) to ensure that it is removed from the optimization. The maximum dose in the target is then set by the CSV, which is set to 125% of the prescribed dose to mimic prescribing the 80% line in conventional SRS. For larger

Target	Matric	Dose contraints
CSV	$D_{1\%}$	Prescribed dose (100%)
PTV	$D_{99\%}$	≥ 80% of precribed dose

SRS treatment planning in Tomotherapy

A TECHNIQUE FOR STEREOTACTIC RADIOSURGERY TREATMENT PLANNING WITH HELICAL TOMOTHERAPY

EMILIE T. SOISSON, PH.D., PETER W. HOBAN, PH.D., THOMAS KAMMEYER, PH.D., JEFFREY M. KAPATOES, PH.D., DAVID C. WESTERLY, PH.D., AMAR BASAVATIA, M.S., and WOLFGANG A. TOMÉ, PH.D.
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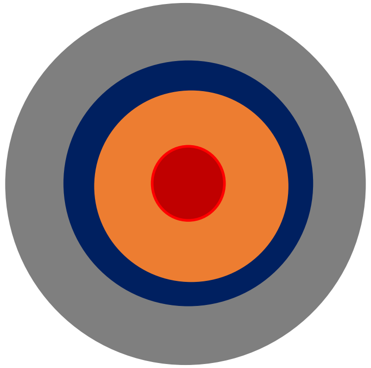


PTV ≤ 2cc

Central sub-volume (CSV)
< 2.5 mm dia.

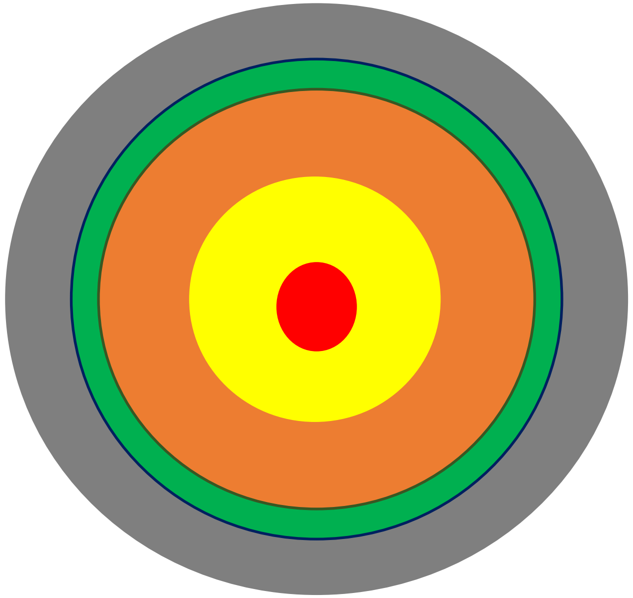
GTV

Sub-volume (SV)
(< 2 cc)

Inner ring (PTV - 2mm)

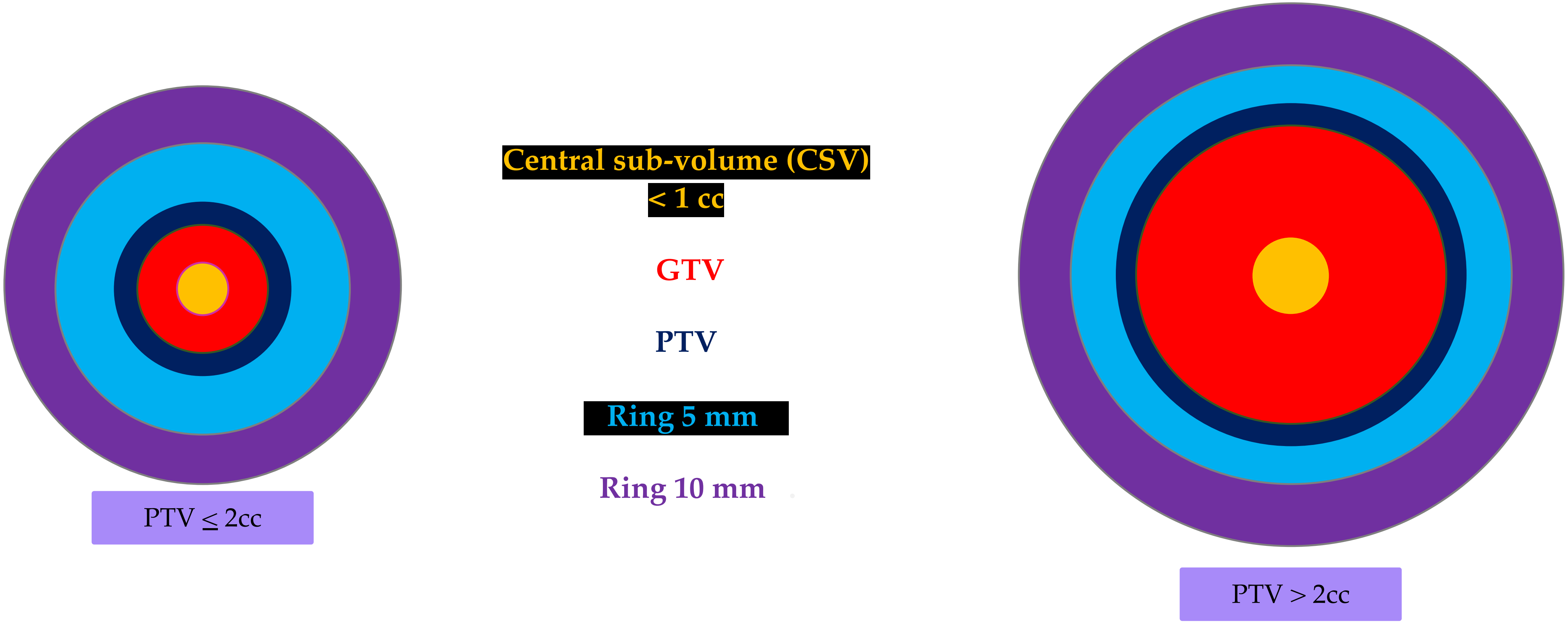
PTV

Ring 3 mm



PTV > 2cc

SRS treatment planning in CMUH



Dose constraints of SRS treatment planning in CMUH

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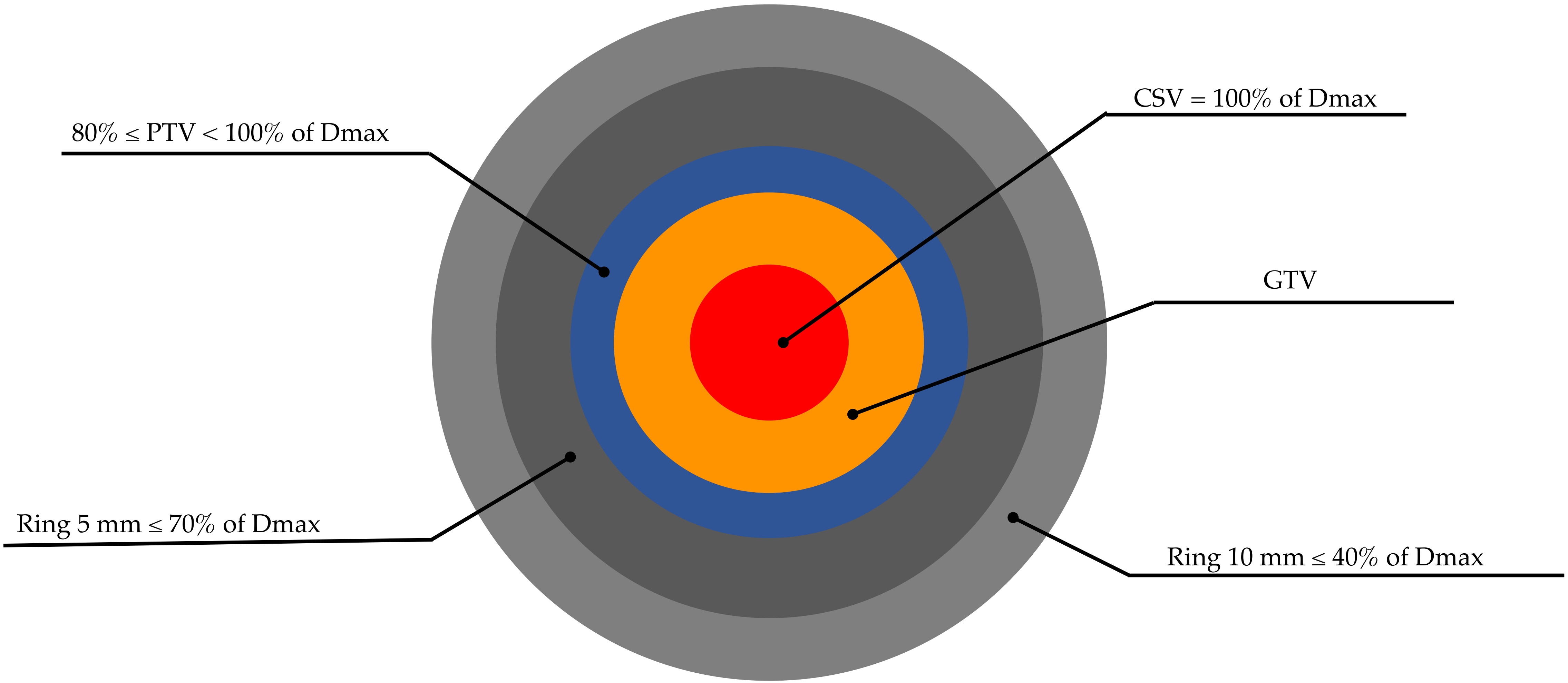
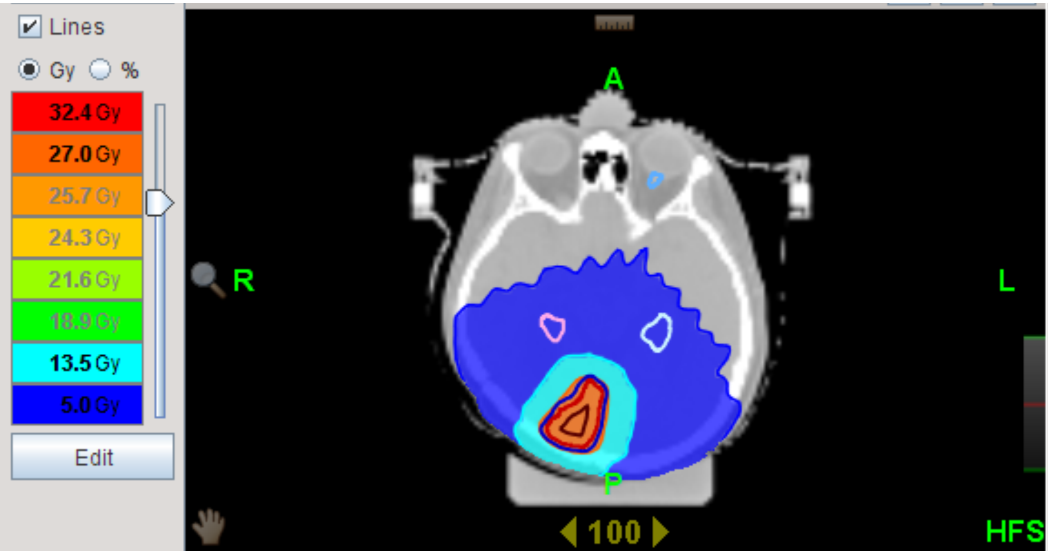
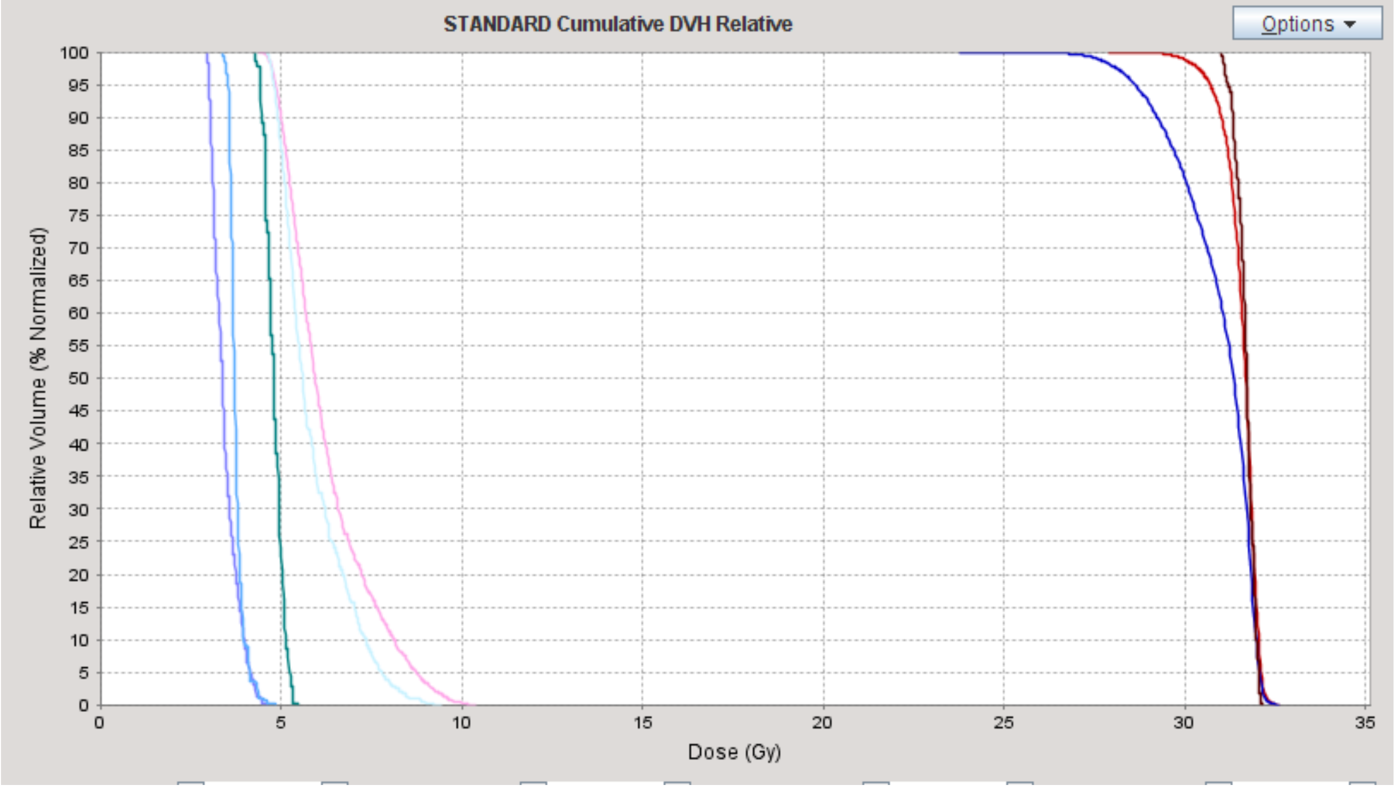
Target



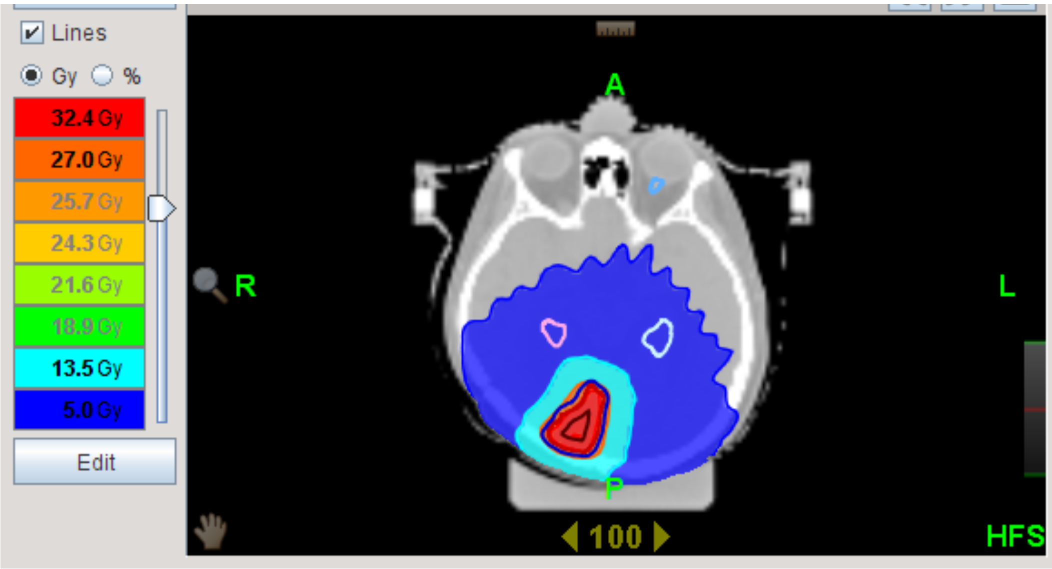
Examples of SRS treatment planning in CMUH



PTV 22.7 cc
SRT 3 Fxs
D_{max} 32.4 Gy
Target dose 27 Gy (83.3% of Dmax)

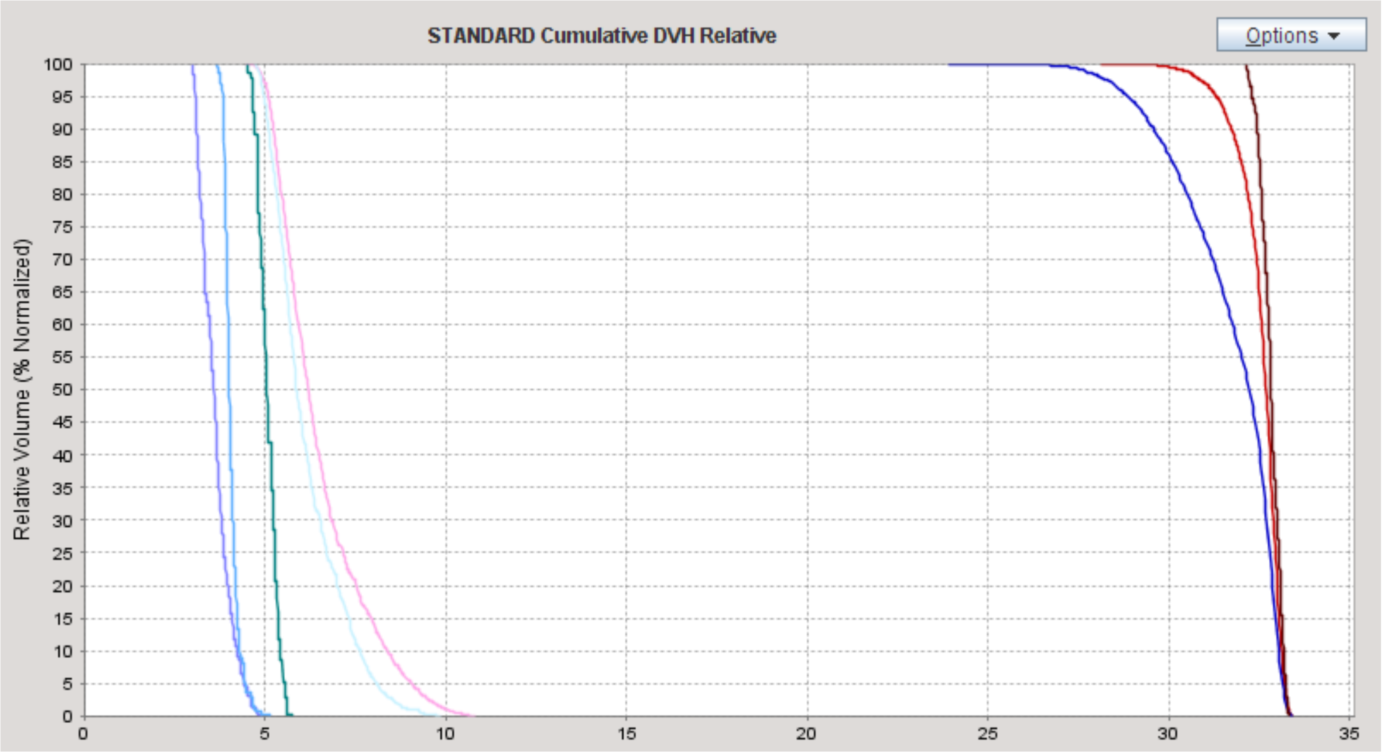


Examples of SRS treatment planning in CMUH



Increase high dose plan

PTV 22.7 cc
SRT 3 Fxs
D_{max} 33.4 Gy
Target dose 27 Gy (80.8% of Dmax)



Evaluation tools

- Conformity index (CI)
- Conformity index at 50% of the treated dose (CI_{50})
- Homogeneity index (HI)
- Conformity Gradient index (CGI)
- Gradient Distance* (GD)

* inhouse evaluation tool

Evaluation tools

Conformity index

Conformity index (ICRU)

$$CI = \frac{PIV}{TV}$$

where
CI = Conformity index
TV = Target volume
PIV = Prescribed isodose volume

Conformity index (Paddrick, 2006)

$$CI = \frac{TV_{TIV}^{2}}{TV \times V_{IR}}$$

where
CI = Conformity index
TV = Target volume
TIV = Target isodose volume
V_{IR} = Treated isodose volume

Evaluation tools

Conformity index at 50%

Conformity index (ICRU)

$$CI = \frac{PIV_{50\%IR}}{TV}$$

where CI = Conformity index
TV = Target volume
PIV = Prescribed isodose volume

Conformity index (Paddrick, 2006)

$$CI = \frac{TV_{TIV}^2}{TV \times V_{50\%\,IR}}$$

where CI = Conformity index
TV = Target volume
TIV = Target isodose volume
V_{IR} = Treated isodose volume

??????

Evaluation tools

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Homogeneity index

$$HI = \frac{D_{max}}{D_{Rx}}$$

where D_{max} = Maximum dose

D_{Rx} = Treated dose

Evaluation tools

Conformity Gradient index

$$CGI = (CGIc + CGIg)/2$$

Where CGI = Conformity gradient index

CGIc = Conformity of CGI

CGIg = Gradient of CGI

PHYSICS CONTRIBUTION

A SIMPLE AND RELIABLE INDEX FOR SCORING RIVAL STEREOTACTIC RADIOSURGERY PLANS

Thomas H. Wagner, Ph.D.,* Francis J. Bova, Ph.D.,† William A. Friedman, M.D.,† John M. Buatti, M.D.,‡ Lionel G. Bouchet, Ph.D.,† and Sanford L. Meeks, Ph.D.‡

Conformity of CGI

$$CGIc = (TV/PIV) \times 100\%$$

Where CGIc = Conformity of CGI

TV = Target volume

PIV = Prescription isodose volume or Treated isodose volume

Gradient of CGI (UFIg)

$$UFIg = 100 - \{100 \cdot [(R_{Eff,50\%Rx} - R_{Eff,Rx}) - 0.3\ cm]\}$$

Where $R_{eff,Rx}$ = Effective radius at treated dose

$R_{eff,50\%Rx}$ = Effiective radius at 50% of treated dose

and, $R_{eff} = \sqrt[3]{\frac{3V}{4\pi}}$

Evaluation tools

Gradient Distance (inhouse formula)

$$GD = R_{eff,50\%Rx} - R_{eff,Rx}$$

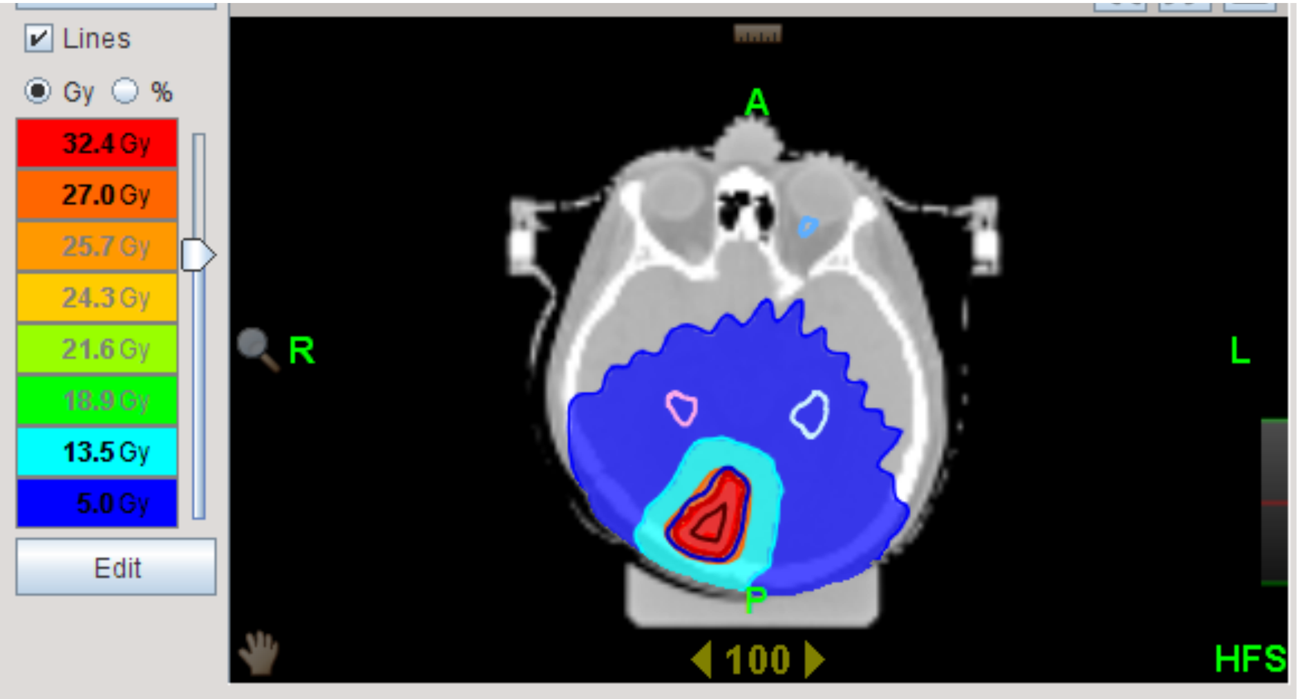
Where GD = Gradient distance

$R_{eff,Rx}$ = Effective radius at treated dose

$R_{eff,50\%Rx}$ = Effiective radius at 50% of treated dose

and, $R_{eff} = \sqrt[3]{\frac{3V}{4\pi}}$

Examples of SRT treatment plan in CMUH



PTV (22.7 cc, R_{eff} = 1.76 cm)
SRT 3 Fxs
Dmax 33.4 Gy
Target dose 27 Gy (80.8% of Dmax)

Parameter	criteria	value
CI_{ICRU}	[redacted]	1.3
$CI_{50,ICRU}$	[redacted]	4.4
HI	[redacted]	1.23
CGI	[redacted]	55.6%
GD	[redacted]	9.7 mm

Consideration issues of Tomotherapy SRS/SRT treatment planning

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Coplanar plan VS Non-coplanar plan

Treatment planar

Non-coplanar tx tech.
Coplanar tx tech.

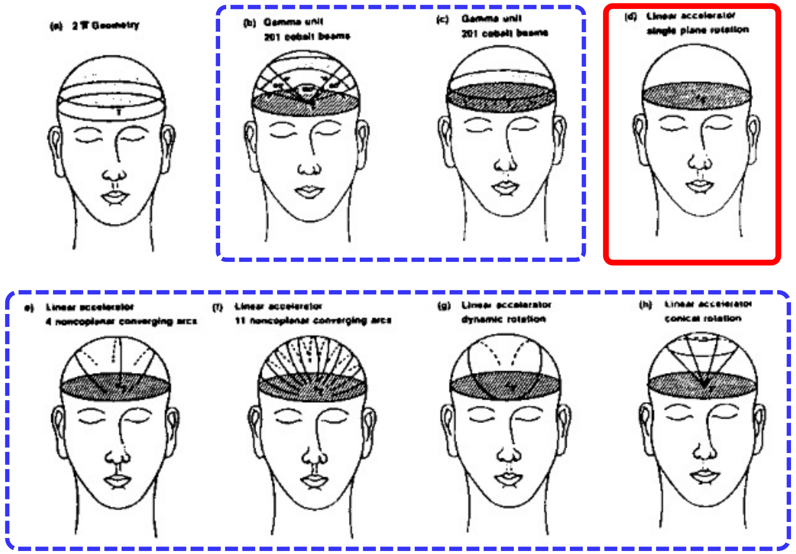

FIGURE 2. Beam-entry patterns on a patient's skull for various radiosurgical techniques. (Podgorsak, E.B. Physics for radiosurgery with linear accelerators, in "Stereotactic Radiosurgery", Chapter 2, pp. 9–34, Neurosurgery Clinics of North America, Vol. 3, edited by D. Lunsford, W.B. Saunders Company, Philadelphia, PA, 1992.)

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Original paper

Dosimetric analysis of Tomotherapy-based intracranial stereotactic radiosurgery of brain metastasis

S. Agostinelli[a,*], S. Garelli[a], M. Gusinu[a], M. Zeverino[b], F. Cavagnetto[a], F. Pupillo[c], A. Bellini[d], G. Taccini[a]

[a] Medical Physics Unit, Ospedale Policlinico San Martino – IRCCS, Largo R. Benzi 10, 16132 Genova, Italy
[b] Institute of Radiation Physics, Lausanne University Hospital, Lausanne, Switzerland
[c] Medical Physics Unit, Ente Ospedaliero Cantonale, Bellinzona, Switzerland
[d] Experimental Medicine Department, Ospedale Policlinico San Martino – IRCCS, Genova, Italy

Based on the aforementioned findings we can say that irradiation of brain metastasis SRS targets with HT, even if limited by its pure coplanar nature, produce a dose distribution with excellent homogeneity, good conformity and a steep dose gradient losing only 1–2 mm if compared with dedicated SRS machines and non-coplanar techniques. The dose gradient in this study has been evaluated using two GSI scores which account for the distance of the 80/50% (typically equivalent to a dose of 16/10 Gy) isodoses from the target and net V9/12/15 Gy volumes. In particular the net V12Gy, the volume of the healthy brain/posterior fossa tissue receiving a dose not inferior to 12 Gy, has been found for single fraction brain SRS to correlate with the risk of radionecrosis [35]. For central lesions treated with a dose of 21 Gy and SJ10

Consideration issues of Tomotherapy SRS/SRT treatment planning

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Coplanar plan

Clinical and radiological response of aggressive dural arteriovenous fistula after combined glue embolization and hypofractionated helical TomoTherapy

Withawat Vuthiwong[1], Anirut Watcharawipha[2,3], Bongkot Jia- Mahasap[2,3], Wannapha Nobnop[2,3] and Imjai Chitapanarux[2,3]

[1]Department of Diagnostic Radiology and Interventional Neuroradiology, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand; [2]Division of Radiation Oncology, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand and [3]Northern Thai Research Group of Radiation Oncology (NTRG-RO), Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand

Table 2. Plan parameters, dosimetric analysis and plan quality index

No.	Dose/Fx, Delivery	PTV (cc)	$R_{eff,PTV}$ (cm)	FW (cm)	Pitch	MF	Dmax (Gy)	Dmin (Gy)	HI	CI	CI_{50}	$R_{eff,Rx}$ (cm)	$R_{eff,50\%Rx}$ (cm)	$R_{eff,50\%Rx\text{-}Rx}$ (cm)
1	30Gy/5Fx, EOD	12·62	1·44	1·0f	0·287	1·80	31·63	27·47	0·14	1·61	6·22	1·69	2·66	0·97
2	30Gy/5Fx, OD	19·01	1·66	1·0f	0·287	1·20	32·22	27·92	0·14	1·47	5·18	1·88	2·86	0·98
3	36Gy/6Fx, EOD	7·70	1·22	2·5f	0·287	1·80	38·15	33·39	0·13	3·05	19·03	1·78	3·27	1·49
4	36Gy/6Fx, EOD	24·45	1·80	1·0f	0·215	1·30	38·44	32·21	0·17	1·60	6·69	2·11	3·39	1·28
5	36Gy/6Fx, EOD	10·74	1·37	1·0f	0·287	1·30	38·43	29·39	0·25	1·91	5·71	1·70	2·45	0·75
6	36Gy/6Fx, EOD	6·93	1·18	2·5d	0·287	2·20	37·28	34·79	0·07	2·70	11·32	1·65	2·66	1·01
7	36Gy/6Fx, EOD	20·20	1·69	2·5d	0·287	1·70	38·57	33·67	0·14	1·53	8·50	1·95	3·45	1·50
8	36Gy/6Fx, EOD	8·28	1·26	1·0f	0·287	1·80	37·71	34·62	0·09	1·58	5·43	1·46	2·21	0·75
9	36Gy/6Fx, EOD	10·16	1·34	1·0f	0·287	1·80	38·70	32·11	0·18	1·37	5·54	1·49	2·38	0·89
10	36Gy/6Fx, EOD	30·65	1·94	2·5d	0·287	1·80	37·39	30·05	0·20	1·56	4·90	2·25	3·30	1·05
11	36Gy/6Fx, EOD	18·52	1·64	1·0f	0·200	2·00	44·15	33·81	0·29	1·40	7·81	1·84	3·26	1·42
Mean		15·39	1·50	-	0·273	1·70	37·52	31·77	0·16	1·80	7·85	1·80	2·90	1·10
SD		7·74	0·25	-	0·032	0·31	3·34	2·64	0·06	0·56	4·16	0·24	0·45	0·28

Abbreviations: Fx, fraction; PTV, planning target volume; R_{effPTV}, effective radius of PTV; FW, field width; MF, modulation factor; Dmax, maximum dose; Dmin, minimum dose; HI, homogeneity index; CI, conformity index; CI_{50}, conformity index at 50% prescribed dose; $R_{eff,Rx}$, effective radius of prescribed dose; $R_{eff,50\%Rx}$, effective radius of 50% prescribed dose; $R_{eff,50\%Rx\text{-}Rx}$, the distance between $R_{eff,50\%Rx}$ and $R_{eff,Rx}$; Gy, grey; EOD, every other day; OD, once a day; SD, standard deviation.

Consideration issues of Tomotherapy SRS/SRT treatment planning

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Coplanar plan

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Dosimetric comparison of large field widths in helical tomotherapy for intracranial stereotactic radiosurgery

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The details of the planning parameters are shown in table 1. The case involved a single lesion value of 80% of the samples, whereas the value for multiple lesions was 20%. The multiple lesions of each case included a lesion value that did not exceed two lesions. The size of the PTV and the distance of the treatment length were 5.53 ± 5.17 cc and 28.94 ± 16.18 mm established by mean ± SD values, respectively. The mean of dose prescription was 17.78±2.78 Gy. The treatment plan was accepted at 83.43% of the D_{max}. The value of the pitch was set at 0.09±0.02, whereas the MF was 1.70.

Table 2. Mean and Standard deviation (Mean ± SD) of the plan quality indexes, dosimetric parameters and BoT.

	FW10f	FW25f	FW25d
Quality index			
Dmin (Gy)	17.50 ± 2.20	17.52 ± 2.34	17.54 ± 2.40
Dmax (Gy)	21.43 ± 2.48	21.38 ± 2.48	21.36 ± 2.47
HI	1.21 ± 0.02	1.20 ± 0.03	1.20 ± 0.03
CI	1.45 ± 0.33	1.53 ± 0.42	1.49 ± 0.37
CI_{50}	8.69 ± 4.11	12.09 ± 6.83	9.60 ± 5.55
GSI	50.32 ± 10.94	**32.96 ± 11.44** ($p < 0.01$)	45.21 ± 14.23
$R_{eff,distance}$ (cm)	0.80 ± 0.11	**0.97 ± 0.11** ($p < 0.01$)	0.85 ± 0.14
Organ at Risk			
Eye (Gy) Right	0.99 ± 1.11	1.87 ± 3.18	0.92 ± 1.07
Left	0.68 ± 0.74	0.83 ± 0.82	0.66 ± 0.74
Brainstem (Gy)	1.97 ± 2.34	2.26 ± 2.37	2.10 ± 2.32
Optic chiasm (Gy)	1.34 ± 1.92	2.06 ± 3.29	1.36 ± 2.04
Optic Nerve (Gy) Right	0.87 ± 1.09	**2.14 ± 3.44** ($p = 0.037$)	0.83 ± 1.06
Left	0.63 ± 0.78	0.92 ± 0.96	0.62 ± 0.79
V_{5Gy} of Whole brain (cc)	98.38 ± 61.52	132.54 ± 79.88	109.68 ± 78.73
ID (Gy×L)	2.84 ± 1.24	**3.76 ± 1.44** ($p = 0.049$)	3.04 ± 1.42
Beam-on time (min)	16.61 ± 4.35	**8.79 ± 1.59** ($p < 0.01$)	**9.29 ± 1.50** ($p < 0.01$)

*Bold letter is the significant difference ($p < 0.05$)

Consideration issues of Tomotherapy SRS/SRT treatment planning

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Stereotactic Ablative Body Radiotherapy (SABR)

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RADIATION ONCOLOGY PHYSICS

Plan quality analysis of stereotactic ablative body radiotherapy treatment planning in liver tumor

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TABLE 3 The dosimetric parameters, indexes, dose constraints, and dose on OARs of all treatment and separated treatment modalities.

	Parameter, (unit)	RTOG constraints	All modalities	HT	VMAT	*P*
PTV	(cc)		60.8 ± 53.9	58.7 ± 49.2	62.4 ± 59.1	
	$V_{100\%}$, (%)	$V_{100\%} \geq 95\%$	97.3 ± 3.9	97.4 ± 2.3	97.3 ± 4.9	
Prescribed dose	(Gy)	–	46.1 ± 6.6	47.1 ± 6.4	45.4 ± 6.9	
HI		–	1.1 ± 0.0	1.1 ± 0.0	1.1 ± 0.1	
$CI_{Paddick}$		–	0.8 ± 0.1	0.9 ± 0.1	0.7 ± 0.2	= 0.002
CI_{ICRU}		–	1.2 ± 0.1	1.1 ± 0.1	1.2 ± 0.2	
CI_{50}		–	5.3 ± 1.1	4.8 ± 0.6	5.7 ± 1.2	= 0.032
$V_{50,100}$		–	4.4 ± 0.6	4.2 ± 0.4	4.6 ± 0.7	
GD	(cm)	–	1.5 ± 0.3	1.4 ± 0.3	1.6 ± 0.3	
$R_{50,100}$		–	1.6 ± 0.1	1.6 ± 0.1	1.7 ± 0.1	
$Liver_{rem}$	(cc)	–	1042.8 ± 257.9	953.4 ± 186.4	1113.1 ± 289.8	
	D_{mean}, (Gy)	Depend on the prescribed dose	10.4 ± 4.0	10.0 ± 4.2	10.8 ± 4.0	
	V_{10Gy}, (%)		38.2 ± 16.8	35.2 ± 16.8	40.5 ± 17.1	
Duodenum	$D_{0.05cc}$, (Gy)	≤ 30.0	12.0 ± 11.1	11.7 ± 14.4	12.1 ± 10.4	
Esophagus	$D_{0.05cc}$, (Gy)	≤ 32.0	11.6 ± 6.7	12.1 ± 8.7	11.2 ± 5.1	
Kidneys	D_{mean}, (Gy)	≤ 10.0	2.8 ± 2.7	3.0 ± 2.9	2.4 ± 2.8	
Bowel	$D_{0.05cc}$, (Gy)	≤ 30.0	11.4 ± 9.5	3.4 ± 2.9	17.4 ± 7.9	= 0.034
Stomach	$D_{0.05cc}$, (Gy)	≤ 30.0	14.6 ± 8.4	14.6 ± 10.2	14.6 ± 7.5	
PRV spinal cord	$D_{0.05cc}$, (Gy)	≤ 25.0	9.9 ± 5.7	9.0 ± 4.7	10.6 ± 6.4	
Surrounding dose	V_{30Gy}, (cc)	–	175.6 ± 130.0	187.2 ± 173.1	166.5 ± 89.3	
Integral dose	(Gy·L)	–	38.5 ± 16.1	36.3 ± 15.8	40.1 ± 16.7	

Abbreviations: HT, Helical tomotherapy; VMAT, Volumetric modulated arc therapy; PTV, Planning target volume; HI, Homogeneity index; $CI_{Paddick}$, Conformity index of Paddick; CI_{ICRU}, Conformity index of ICRU; CI_{50}, Conformity index at 50% prescribed dose; $V_{50,100}$, Volume ratio between 50% and 100% isodose level; GD, Gradient distance; $R_{50,100}$, Distance ratio between effective distance of 50% and 100% isodose level; $Liver_{rem}$, Remaining liver and PRV, Planning organ at risk volume.

Consideration issues of Tomotherapy SRS/SRT treatment planning

Beam on time

A Technique for Stereotactic Radiosurgery Treatment Planning with Helical Tomotherapy

Emilie T. Soisson, Ph.D.[1,2], Peter W. Hoban, Ph.D.[3], Thomas Kammeyer, Ph.D.[3], Jeffrey M. Kapatoes, Ph.D.[3], David C. Westerly, Ph.D.[1], Amar Basavatia, M.S.[2], and Wolfgang A. Tomé, Ph.D.[1,2,*]

Initial Plan Parameters—All plans were calculated using the "Fine" dose grid, resulting in a dose voxel size of 1.41mm × 1.41mm × 1.25mm (where image pixels are directly used as dose voxels). A field width of 10 mm was used for treatment planning to maximize the rate of dose falloff at the superior and inferior boundaries of the target.

Consideration issues of Tomotherapy SRS/SRT treatment planning

Beam on time

Helical tomotherapy optimized planning parameters for nasopharyngeal cancer

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Journal of Physics: Conference Series **694** (2016) 012002 doi:10.1088/1742-6596/694/1/012002

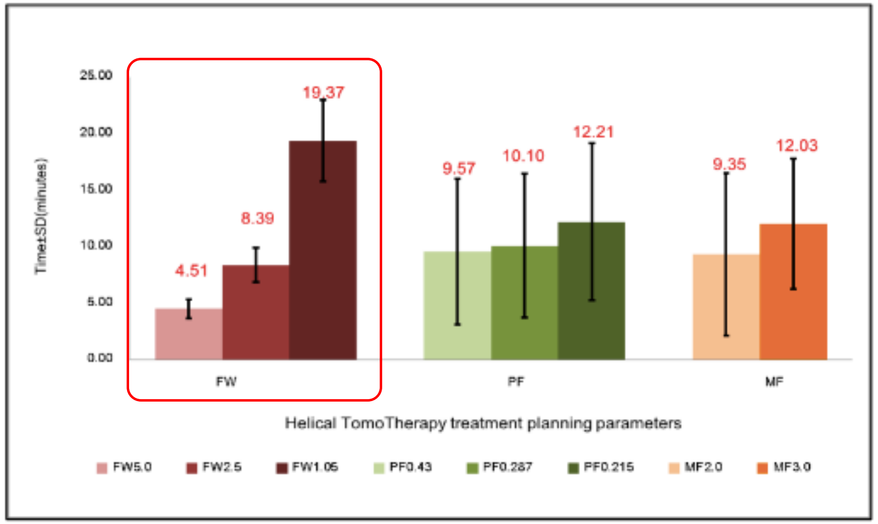

Figure 4. The average treatment times per fraction with different optimize parameters.

$$\text{Beam on time} \propto \frac{1}{\text{Field Width}}$$

Consideration issues of Tomotherapy SRS/SRT treatment planning

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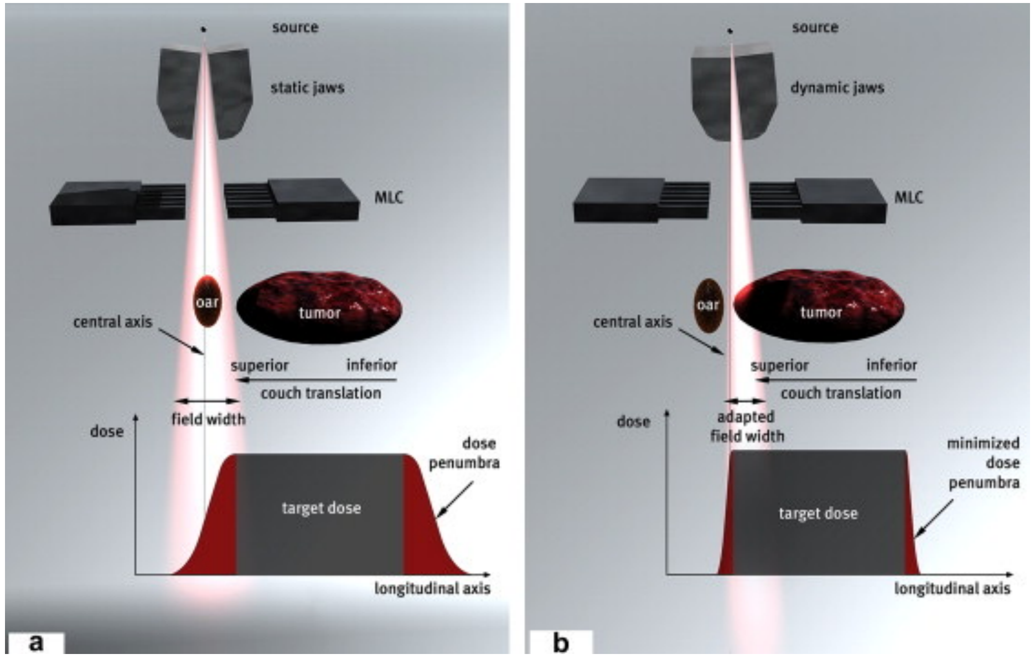
Beam on time

Efficacy of stereotactic radiotherapy for brain metastases using dynamic jaws technology in the helical tomotherapy system

[1]TARO MURAI, MD, [2]AKIHIRO HAYASHI, MD, [1]YOSHIHIKO MANABE, MD, [1]CHIKAO SUGIE, MD, [1]TAIKI TAKAOKA, MD, [1]TAKESHI YANAGI, MD, [3]TETSUYA OGURI, MD, [1]MASAYUKI MATSUO, MD, [4]YOSHIMASA MORI, MD and [1]YUTA SHIBAMOTO, MD

Treatment system		1.0-cm FJ	2.5-cm DJ	*p*-value
BM number		34	34	
PTV (cc)	(mean ± SD)	7.2 ± 9.3	8.6 ± 11.3	0.89
	<1	9	8	
	≥1, <4	8	9	
	≥4, <15	11	11	
	≥15	6	6	
Fraction number	30 Gy/3 fr	5	6	
	35 Gy/5 fr	12	14	
	37.5 Gy/5 fr	17	14	
CI (mean ± SD)		4.9 ± 12.7	2.2 ± 1.7	0.53
UI (mean ± SD)		1.1 ± 0.07	1.1 ± 0.06	0.41
Monitor unit[a] (mean ± SD)		7910 ± 2434	5484 ± 1186	<0.001
Time (s)[a] (mean ± SD)		559 ± 164	395 ± 83	<0.001

Required



Dynamic jaws

Consideration issues of Tomotherapy SRS/SRT treatment planning

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Beam on time (Plan qualities VS Field width)

FW 2.5 dynamic

Efficacy of stereotactic radiotherapy for brain metastases using dynamic jaws technology in the helical tomotherapy system

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FW 2.5 Fixed

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Original paper

Dosimetric analysis of Tomotherapy-based intracranial stereotactic radiosurgery of brain metastasis

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Consideration issues of Tomotherapy SRS/SRT treatment planning

CHIANG MAI UNIVERSITY

Beam on time (Plan qualities VS Field width)

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Dosimetric comparison of large field widths in helical tomotherapy for intracranial stereotactic radiosurgery

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fixed-FW 10 mm (FW10f), fixed-FW 25 mm (FW25f), and dynamic-FW 25 mm (FW25d). PTV was prescribed within a range of 15-20 Gy for a single fraction. The coverage of the prescribed dose was at least 99% of the PTV and 100% of the GTV. Plan parameters were set according to the recommendations of Soison *et al* (11). The value of the

Fixed jaws in a large field width of Tomotherapy => Plan qualities ⇩

Table 2. Mean and Standard deviation (Mean ± SD) of the plan quality indexes, dosimetric parameters and BoT.

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*Bold letter is the significant difference ($p < 0.05$)

Summary

- Tomotherapy can be an alternative modality for SRS/SRT.
- Fixed field width of 10 mm of tomotherapy is the goal standard of SRS/SRT.
- The different distance of the steep dose gradient is only 1-2 mm between the non-coplanar technique by c-arm based Linac and the coplanar technique by tomotherapy.
- Dynamic FW of 25 mm provides not only the treatment time reduction but also the parallel plan qualities on the fixed field width of 10 mm.
- Fixed FW of 25 mm can be used with the consideration of the clinical practice.

Thank you for your attentions.