Principle and Practice of Image-Guided SRS/SRT

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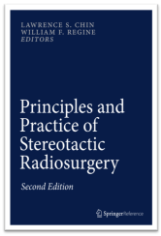
Moving What for SRS/SRT ?

Beam ☐ Skull ☑
Beam ☑ Skull ☐

Beam ☑ Skull ☑
Beam ☐ Skull ☐

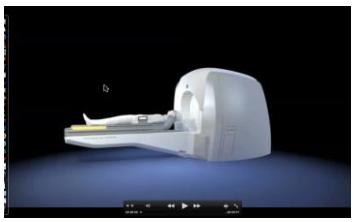


State-of-the-Art Platforms

Ideal Design for SRS/SRT

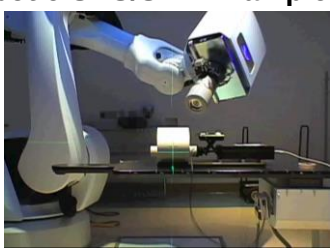
- Short source-focal length (minimizing penumbra)
- Multi-isocenter capability (central targeting)
- High number of beams (sharpening dose gradient)
- No translation and rotation uncertainty (robust tx)

Classic SRS/SRT Example: LGK



Courtesy of Elekta AB 2006

Robotic SRS/SRT Example: CKS



Courtesy of Dr. Chris McGuinness UCSF

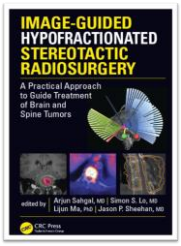
VMAT-based SRT/SBRT Example

- FFF driven output
- HD MLC
- Variable Gantry Rotations

Courtesy of
Varian Oncology

Imaging Guidance + Hypofractionation

- High precision delivery leveraging the power of image guided 6DOF alignments
- Hypofractionation leveraging enhanced biological effects



Radiobiological Rationales

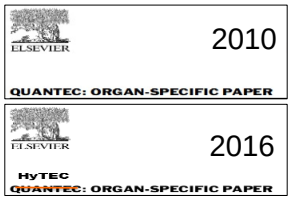
- Single fraction

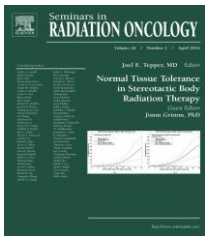
  Small Lesion, No 4Rs

- Hypofractionation

  Larger Lesion;
  Reoxygenation &
  Reassortment

Hypofractionation Tissue Effects in Clinic (HyTEC)



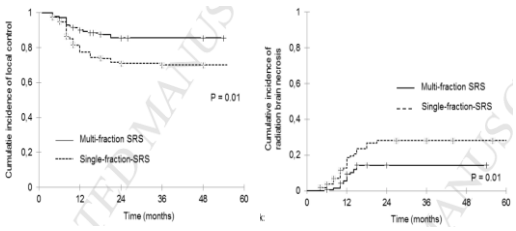


Hypofractionated Brain Mets SRS/SRT

	1 x 15-18 Gy	3 x 9 Gy	p
Pts	151	138	
Mets	1-4	1-4	ns
GTV (cc)	9 (3-24)	13 (4-48)	0.001
LC (12 mo)	77%	90%	0.01
RN (12 mo)	18%	9%	0.01

Minniti G etal, Int J Radiat Oncol Phys 95(4)1142-8 July 15, 2016

Results



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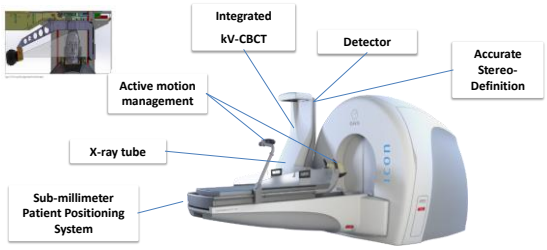
GOLD STANDARD REDEFINED

Precision SRS/SRT via Online Adaptive Dose Control

US Arrival: Spring 2016

Courtesy of Elekta AB

Physical Characteristics



Major Workflow Features

IMMOBILIZATION
– frame or frameless

TREATMENT PARADIGM
– single session or fractionation

TARGET TYPE
– volume, number and location

CLINICAL MODE
– radiosurgery or ultra-precise microradiosurgery

Maintain Focusing and Normal Brain Sparing Advantage

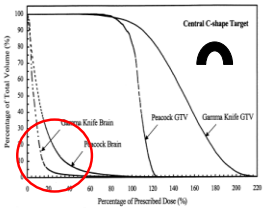
PII S0360-3016(99)00340-8

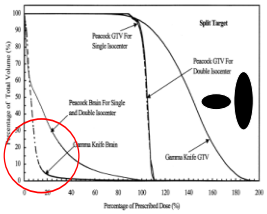
1999 IJROBP 45(5)

PHYSICS CONTRIBUTION

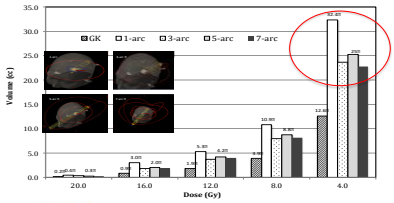
A DOSIMETRIC COMPARISON OF FAN-BEAM INTENSITY MODULATED RADIOTHERAPY WITH GAMMA KNIFE STEREOTACTIC RADIOSURGERY FOR TREATING INTERMEDIATE INTRACRANIAL LESIONS

Low-Dose Spillage Effect





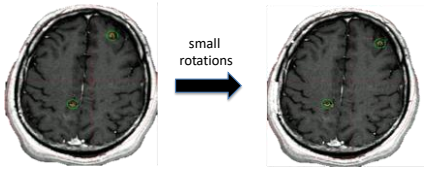
Multiple Targets: Multiplied Effect



Variable dose interplay effects across radiosurgical apparatus in treating multiple brain metastases

Rotational Misalignment Issue

GKSRS



VMAT


Physics Contribution

Single-Isocenter Multiple-Target Stereotactic Radiosurgery: Risk of Compromised Coverage

Justin Roper, PhD[*], Vorakarn Chanyavanich, PhD[*], Gregory Betzel, PhD[*], Jeffrey Switchenko, PhD[†], Anees Dhabaan, PhD[*]

Summary

- Image-guided FFF-based modulated beam delivery (e.g. VMAT) has dominated linac-based SRS/SRT
- Image-guided GK Icon is redefining the gold standard for ultra-precise intracranial SRS/SRT