

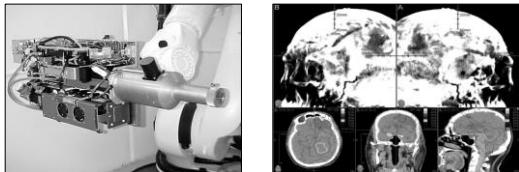
Robotic Brain and Spine SRS/SBRT

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Genesis of Robotic Frameless SRS/SRT

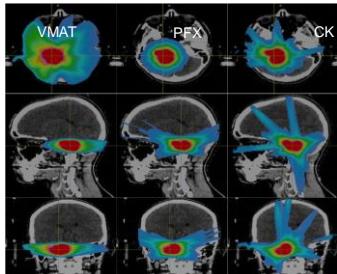


Adler J R, Jr., Murphy M J, Chang S D and Hancock S L 1999
Image-guided robotic radiosurgery
Neurosurgery **44** 1299-306; discussion 306-7

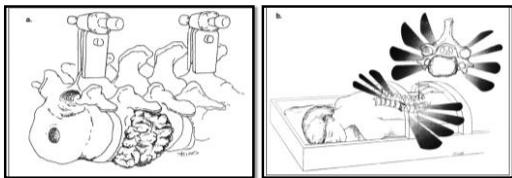
Integrated Stereo-imaging is the Key



Example: Large Met SRT (25 Gy/5 Fx)

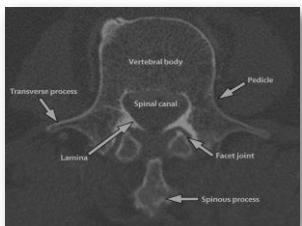


Genesis of Spine SBRT



SPINO Review: Lancet Oncol 2015 DOI: [http://dx.doi.org/10.1016/S1470-2045\(15\)00166-7](http://dx.doi.org/10.1016/S1470-2045(15)00166-7)

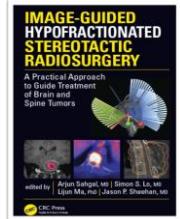
Spine Anatomy



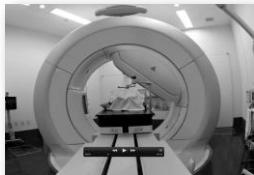
SPINO Review: Lancet Oncol 2015 DOI: [http://dx.doi.org/10.1016/S1470-2045\(15\)00166-7](http://dx.doi.org/10.1016/S1470-2045(15)00166-7)

Image-Guided Hypofractionated Spinal SRS/SBRT

- Imaging guidance key to precise set up and motion managements
- Hypofractionation to minimize spinal cord dose & vertebra body fracture risks

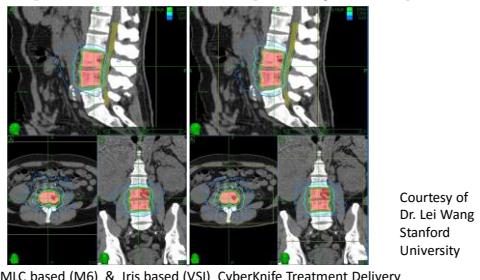


Robotic Beam-Tracking Platforms



Cyberknife (USA) vs Vero 4DRT (JPN)

Example: 2VB SBRT (20 Gy/1 Fx)

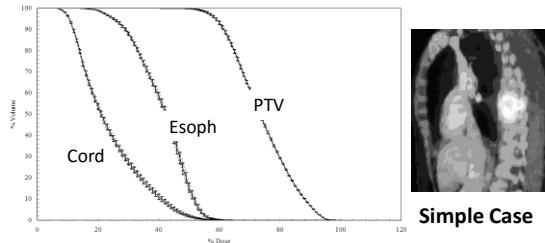


MLC based (M6) & Iris based (VSi) CyberKnife Treatment Delivery

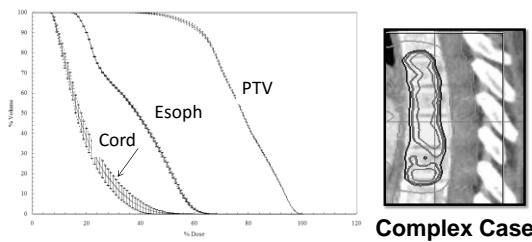
Key Features

System	Characteristics
CyberKnife	<ul style="list-style-type: none"> Active Feedback Beam Control Cone, Iris, MLC 2D Stereoscopic kV real-time imaging 6D Robotic Couch
Vero 4DRT	<ul style="list-style-type: none"> 60 deg O-ring Gantry; Gimbaled Source MLC only 3D CBCT +/- 2D kV +/- Surface markers 5D Robotic Couch

Effect of Residual Motion Uncertainty



Effect of Residual Motion Uncertainty



Key Points For Practice

- Human spinal cord at this time should be considered as an organ functioned in series
- Dose to the point maximum PRV or thecal sac should be respected

Sagal, Lo, Ma and Sheehan: Image-Guided Hypofractionated SRS Ch 21.6, pg 330 (2016)

Spinal Cord PRV Dose Limits

SBRT number of fractions	Point maximum volume limit (Gy)			
	No prior radiotherapy		Prior radiotherapy	
	≤1% risk of RM	≤5% risk of RM	30 Gy in 10 fx	50 Gy in 25 fx
1	9.2	12.4	9.0	NA
2	12.5	17.0	12.2	11.0
3	14.8	20.3	14.5	12.5
4	16.7	23.0	16.2	14.0
5	18.2	25.3	18.0	15.5

Rule of Thumb: TD(5%) = 1 + 11 * Sqrt (Fractions)

Sagal, Lo, Ma and Sheehan: Image-Guided Hypofractionated SRS Ch 21.6, pg 328 (2016)

Consulting Authors

Joel E. Tepper, MD *Editor*

Normal Tissue Tolerance in Stereotactic Body Radiation Therapy

Guest Editor
Jimm Grimm, PhD

NTCP for SBRT

• 1500 cases

• 1-5 fractions

- CyberKnife
- Gamma Knife
- or LINAC

• With 60+ authors

• From 15 institutions

• 10 anatomical structures

Courtesy of Jimm Grimm



Estimated Risk Level of Unified Stereotactic Body Radiation Therapy Dose Tolerance Limits for Spinal Cord

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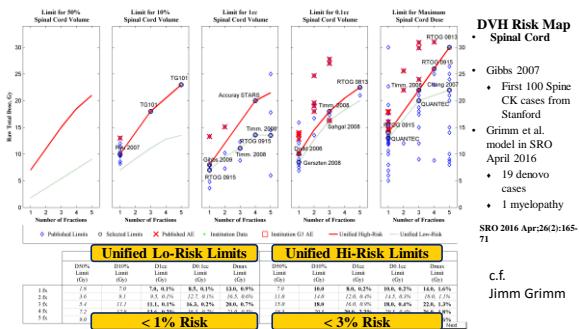
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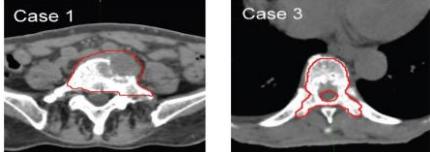
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CyberKnife vs Vero Planning Study

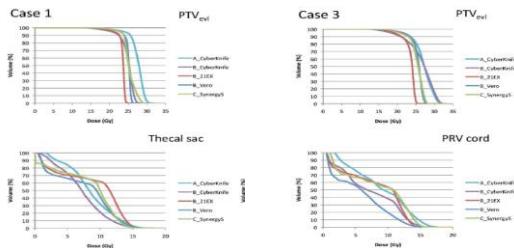


Evaluating dosimetric differences in spine stereotactic body radiotherapy: An international multi-institutional treatment planning study¹

Tomohisa Furuya, PhD¹, Hiroshi Tanaka, MD¹, Mark Ruschin, PhD², Keiji Nihei, MD¹, Dilini Pinnaduwage, PhD³, Lijun Ma, PhD³, Arjun Sahgal, MD³ and Katsuyuki Karasawa, MD¹

Best Young Investigator Paper Award in 2015 ISRS Biannual Congress in Yokohama, JPN

CyberKnife vs Vero Results



Summary

- Robotic SRS/SRT utilizes fast 2D stereoscopic imaging (Cyberknife) as well as 3D CBCT (Vero)
- Data supports limiting point max and/or small volume spinal cord dose in SBRT

