Spinal Radiosurgery for Tumors: A Minimally Invasive Approach

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GEORGIA CANCER COALITION DISTINGUISHED SCHOLAR
March 12, 2010

Outline

- Overview of Radiosurgery- A Neurosurgeon's Perspective
- Rationale for Linac Spinal Radiosurgery
  - Metastatic tumors
  - Postoperative adjuvant
  - Benign tumors
- Importance of Multimodal Imaging and Registration
- Precise Patient Positioning
- Multimodal Treatment (Case Example)
  - Surgical Resection Combined w/Linac
- RTOG Spine Radiosurgery Clinical Trial

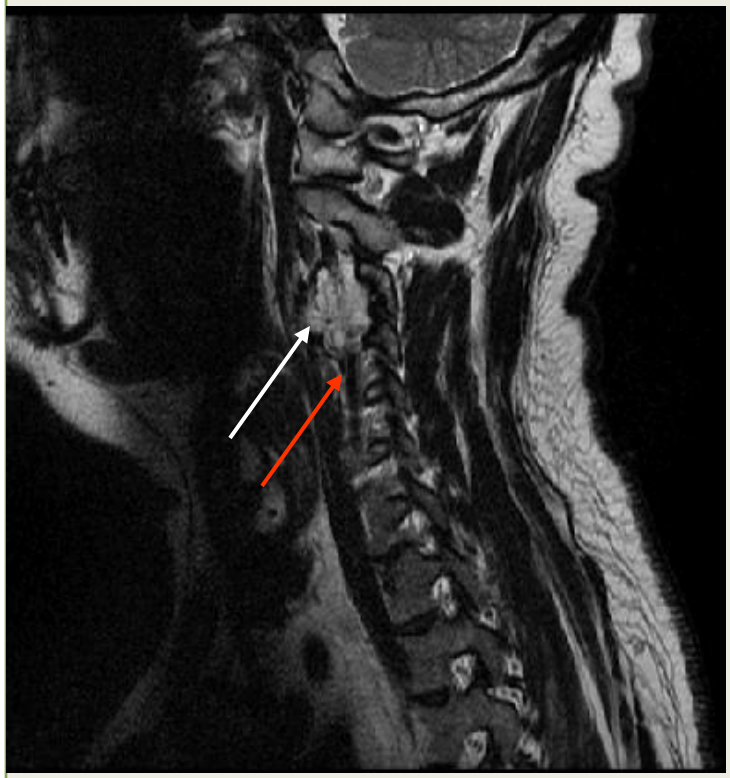
What is Spinal Radiosurgery?

- Also known as stereotactic body radiation therapy (SBRT) and extracranial radiosurgery
- Form of extracranial radiosurgery
- Image-guided frameless technology
- Performed with modified linear accelerators (Clinac)
- Different technologies available:
- Trilogy (Varian, Inc.) and Novalis Tx
- Cyberknife (Accuray, Inc.)
- Axesse (Elekta AB)
- TomoTherapy Hi-Art (TomoTherapy, Inc.)

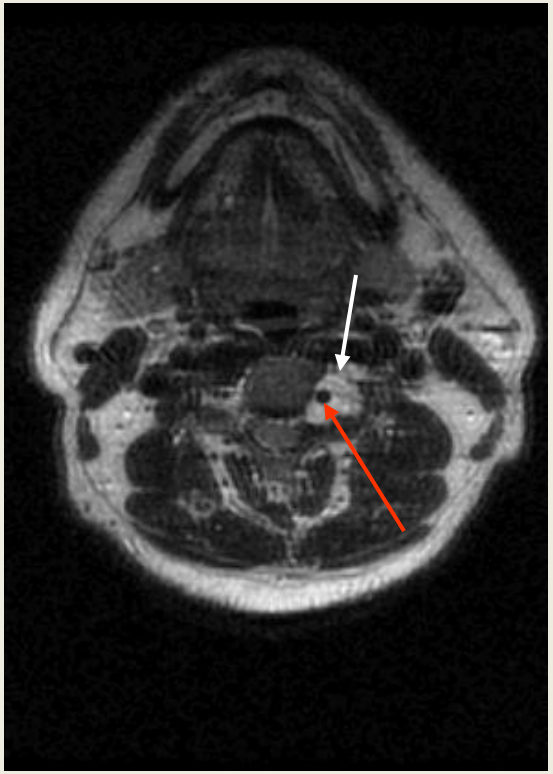
Why Do We Treat With Radiosurgery?

- High surgical risk to patient (e.g., vascular compromise)
- Tumor accessible but patient not a candidate for surgery for medical reasons.
- Tumor accessible but patient prefers SRS to conventional surgery due to:
- Less invasive nature of procedure
- Less frequent complications
- Potential improved outcomes

High Surgical Risk



L C3-4 Nerve Sheath Tumor Causing Radiculopathy



Encasing Vertebral Artery

18 Mos After Spinal Radiosurgery

Extracranial Radiosurgery?

- Natural extension of intracranial radiosurgery
- More complicated
- Larger treatment volumes
- Inability to utilize rigid, frame-based immobilization
- Numerous organs at risk (ex. Spinal cord)

Extracranial Radiosurgery for Spinal Lesions

- Frameless image-guided radiosurgery has permitted the treatment of spinal tumors.
- Linear-accelerator derived single fraction radiosurgery has been used to treat spinal tumors (mainly spine metastases).
- Conformal delivery methods have been used to limit spinal cord radiation dose (<10 Gy) while maintaining tumor dose.
- Advent of intensity-modulated radiation therapy (IMRT) can provide high accuracy in achieving target dose conformation while sparing spinal cord.
- Radioopaque fiducials and direct imaging of vertebral anatomy have been used for treatment planning and administration.
- Moldable patient cushions used to immobilize patients to reduce target motion with respiration
- Target accuracy can be < 2mm

Yin FF et al. *Med Phys* 2002.
Ryu S et al. *Cancer* 2007.

Why Treat Spine Metastases with Radiosurgery?

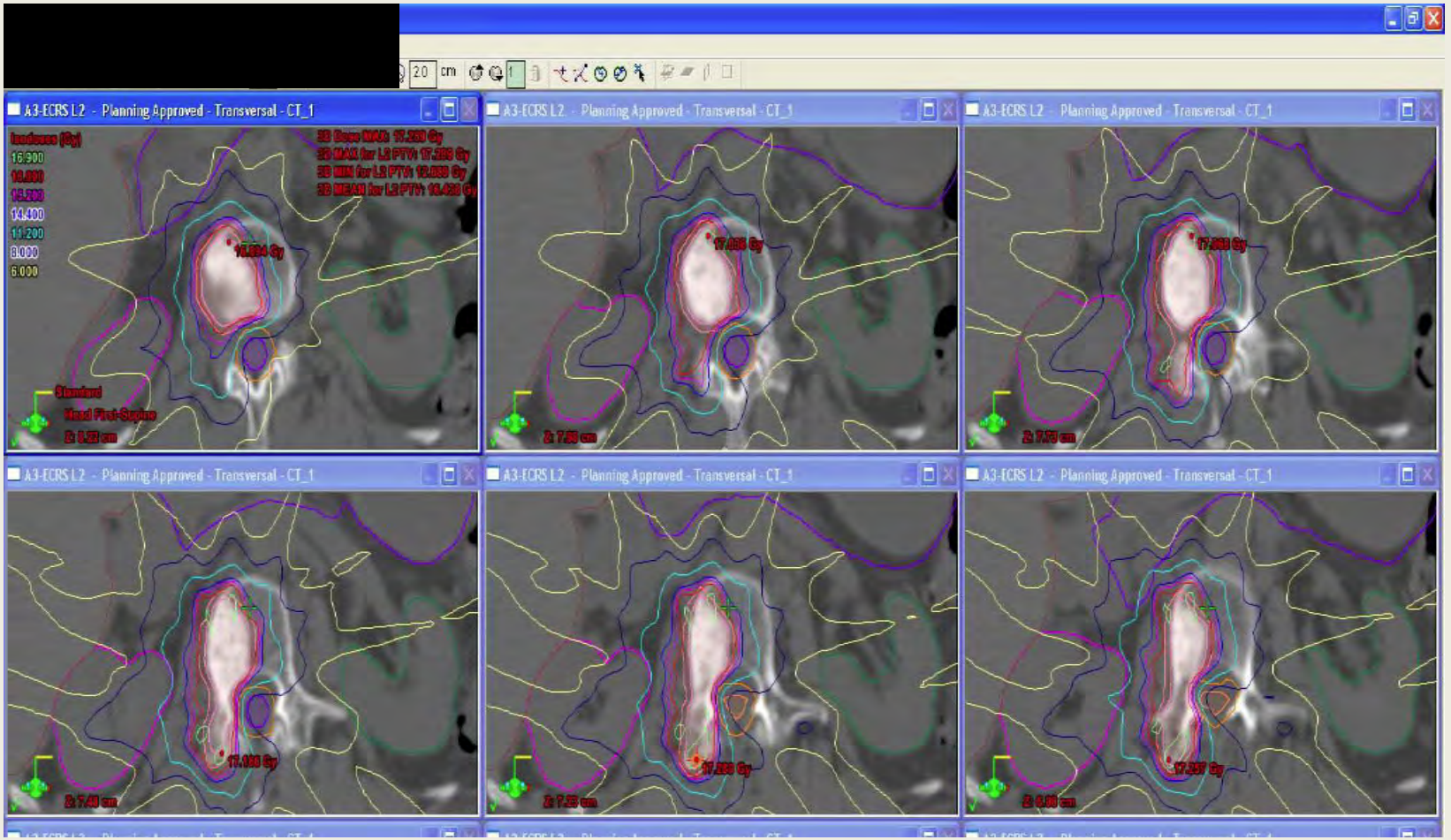
- Common complication of cancer
- Spinal bone pain is the most common presentation and patients can have paraspinal or epidural mass.
- Radiosurgery can provide rapid pain relief (14 d) and neurologic improvement in pts with our w/out epidural spinal cord compression.
- Tumor recurrence rare in treated areas after radiosurgery
- Need to improve pain control in pts with spine mets and increase quality of life.
- Most common regimen of radiotherapy has been 30 Gy in 10 fractions.
- Single dose of 8-10 is equivalent to a fractionated regimen of 30 Gy in 10 fractions (3 Gy fractions).

Wu JS et al. *Int J Radiat Oncol Biol Phys* 2003.
Patchell R et al. *Lancet* 2005.
Ryu S et al. *Cancer* 2007.

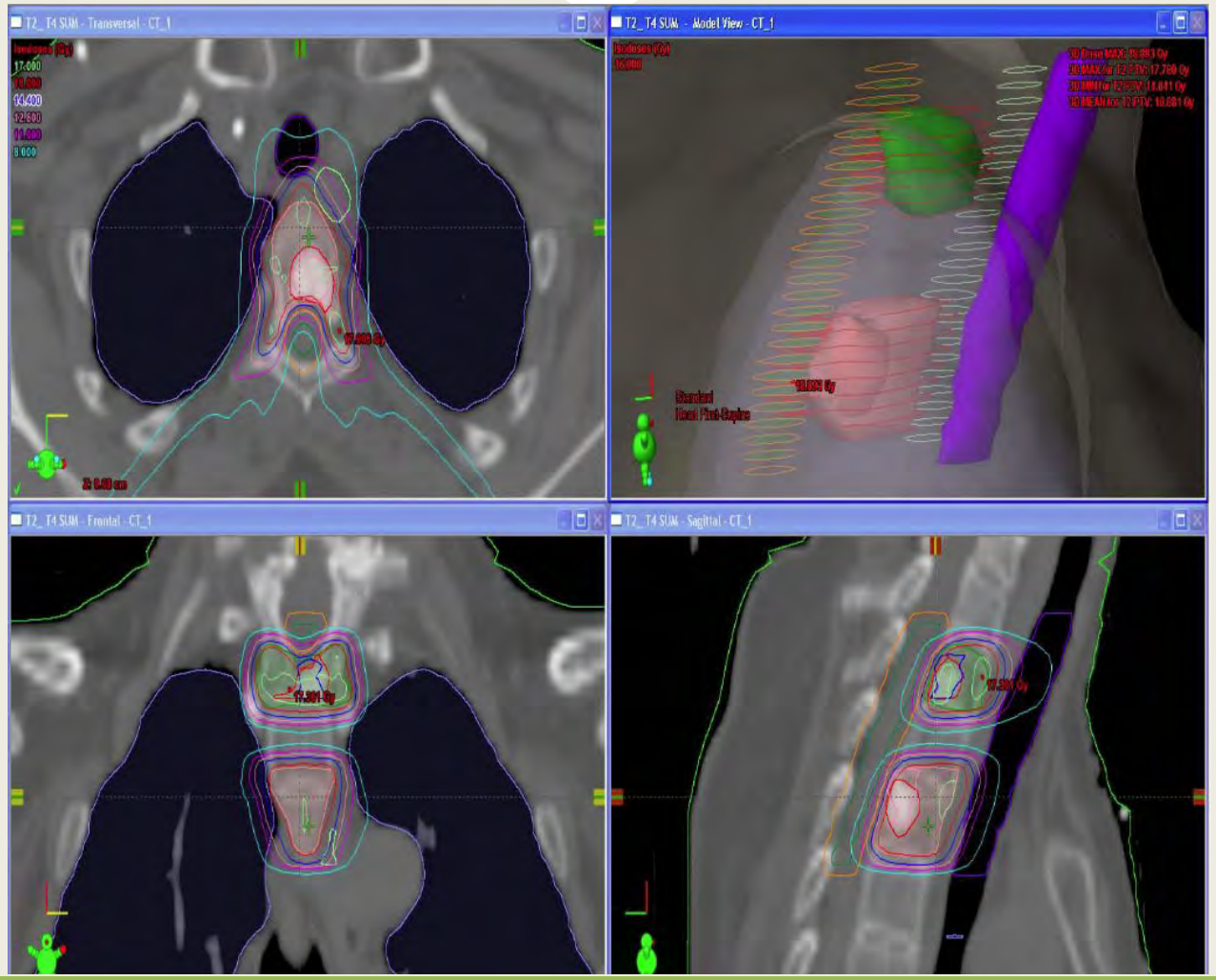
Typical Indications for Spinal Radiosurgery

- No biomechanical instability
- No significant cord compression
- Minimal neurological deficits
- Diagnosis known
- Metastatic dz involving 2 or less spinal levels that are contiguous
- Can perform radiosurgery for separate spine sites

Spinal Radiosurgery for Spine Met



Spinal Radiosurgery for Multiple Spine Mets

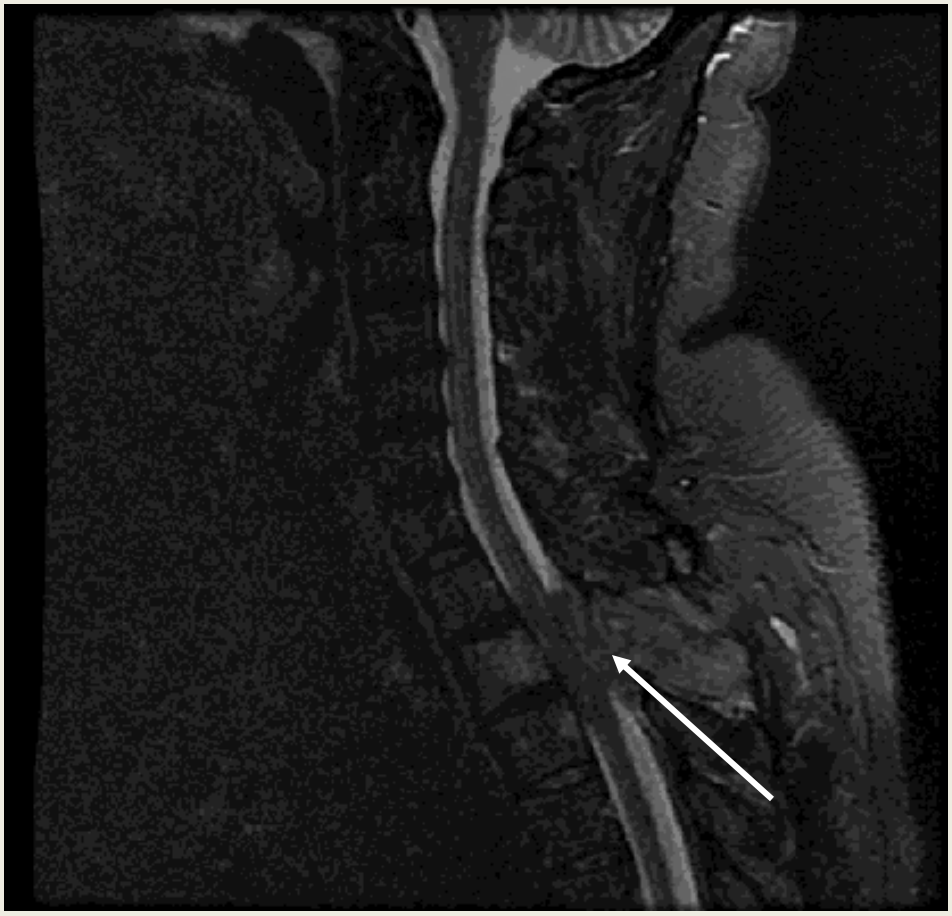


Open Spinal Surgery Still Indicated For:

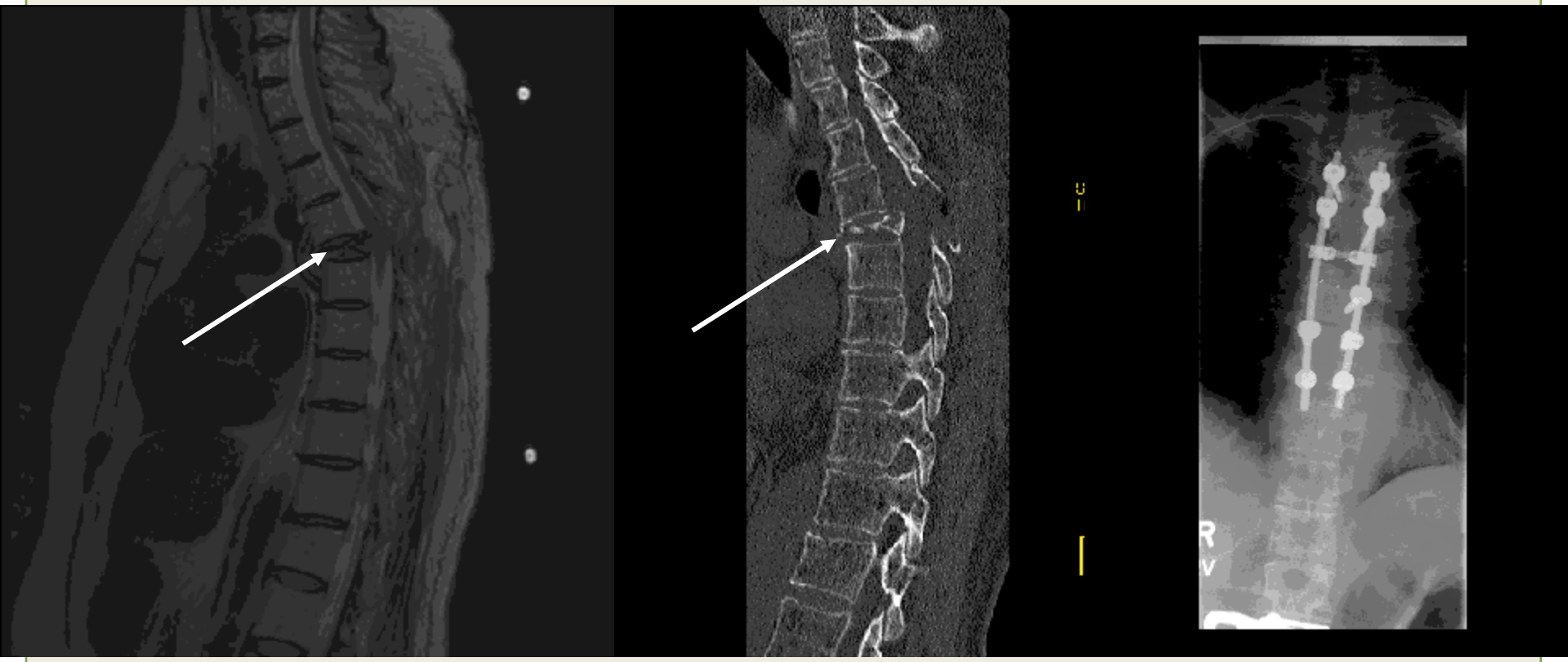
- Spinal instability (fracture, dislocation) from vertebral tumor involvement
- Acute or progressive neurologic deficits
- Significant spinal cord compression
- Intractable pain
- Need for tissue dx
- Patchell study (Surgical decompression and fractionated XRT vs. fractionated XRT)
- Randomized trial with 101 pts
- More pts in surgery group able to walk after tx
- Pts in surgery group retained ability to walk longer after tx
- Need for steroids reduced in surgery group
- 32 pts entered study and unable to walk, 62% of surgery group regained ability to walk while 19% in XRT group regained walking ability

Patchell R. *Lancet* 2005.

Spinal Cord Compression



Spinal Instability



Preop MRI

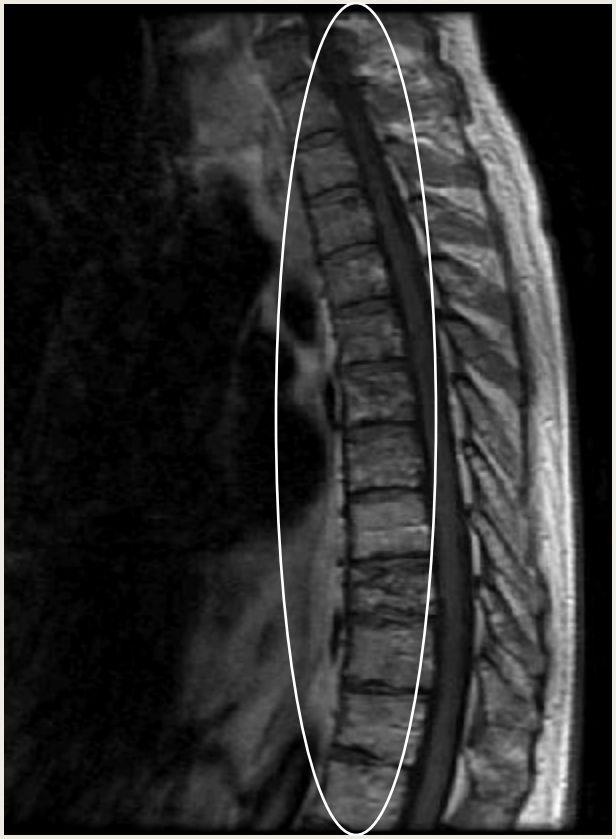
Preop CT

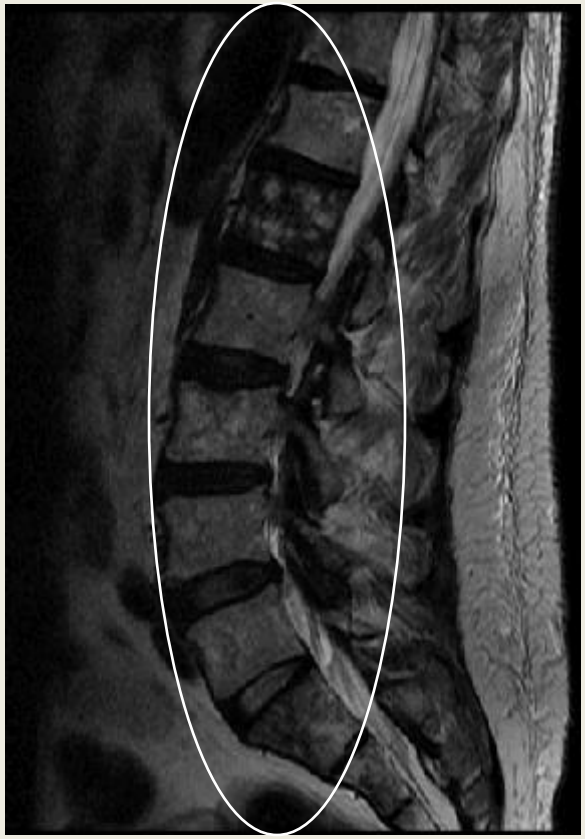
Postop X-ray

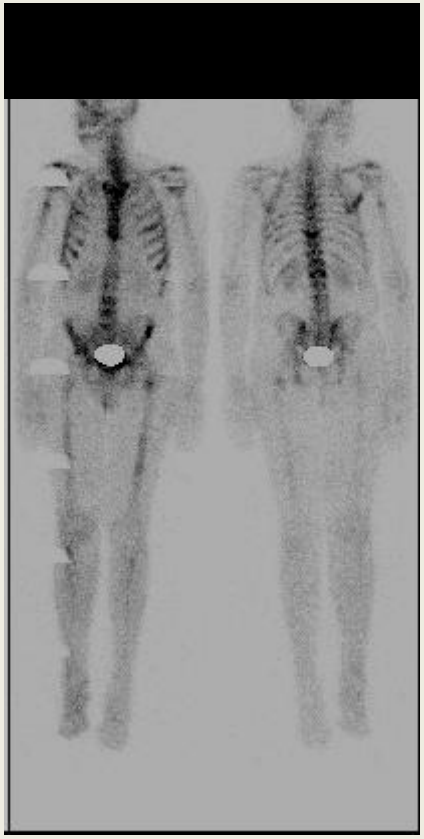
Fractionated External Beam Radiation Therapy Still Needed For…

- Extensive spinal tumor involvement
- Poor performance status
- Palliative approach (<3 mos expected survival)

Extensive Spinal Tumor Involvement







Diffuse Prostate Spinal Mets

Limitations of Spinal Radiosurgery

- Accuracy of localization may be different between simulation/planning to the end of treatment.
- Patient positioning and motion
- Motion can occur between planning and treatment
- Motion can occur with respiration or patient movement
- Lack of high quality 3-dimensional imaging capabilities for pretreatment planning (need for fusion of MRI with planning CT)

Trilogy and Novalis Tx Linear Accelerator

- Higher dose rate (1000 MU/min)
- Remote couch motion
- Tighter isocenter (twice as precise compared to conventional linac modified for SRS treatments)
- OBI allows for radiographic verification of patient/target position prior to treatment
- Cone Beam CT module
- May integrate respiratory gating for extracranial application

Patient Positioning at Emory University

- Precise positioning for spinal radiosurgery cannot be accomplished with manual radiographic matching.
- OBI (on-board imaging) system used for both radiographic and cone-beam CT (CBCT) image guidance.
- Steps:

1. Initial matching of radiograph (KV) in-room images with the planning CT (pCT) generated images.
2. Followed by manual matching of the CBCT to the pCT.
3. Final match permits treatment table adjustment and accurate dosing and targeting of spine lesion.

Treatment Steps for Spinal Radiosurgery

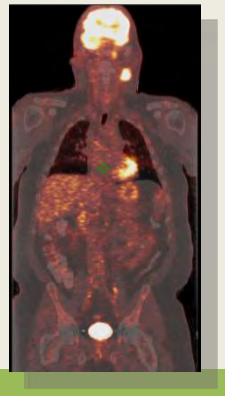
- Definition of anatomical target and radiation sensitive structures
- Design of a conformal plan
- Determination of dose for effective pain control (16-18 Gy for spine mets) and tumor control
- Immobilization
- Verification of treatment
- Delivery of treatment

Spinal Radiosurgery Treatment Process

MRI

Simulation

PET



Anatomy Map

Planning

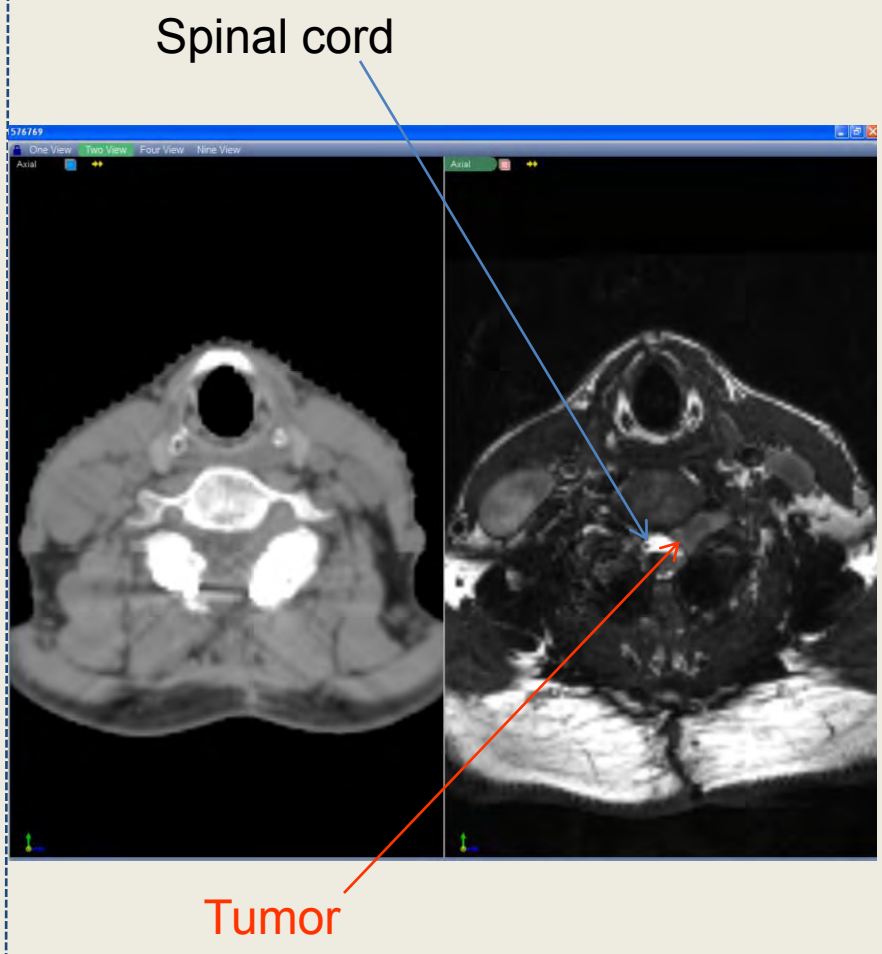
Planning (Eclipse and Velocity Software)

Delivery/Verification

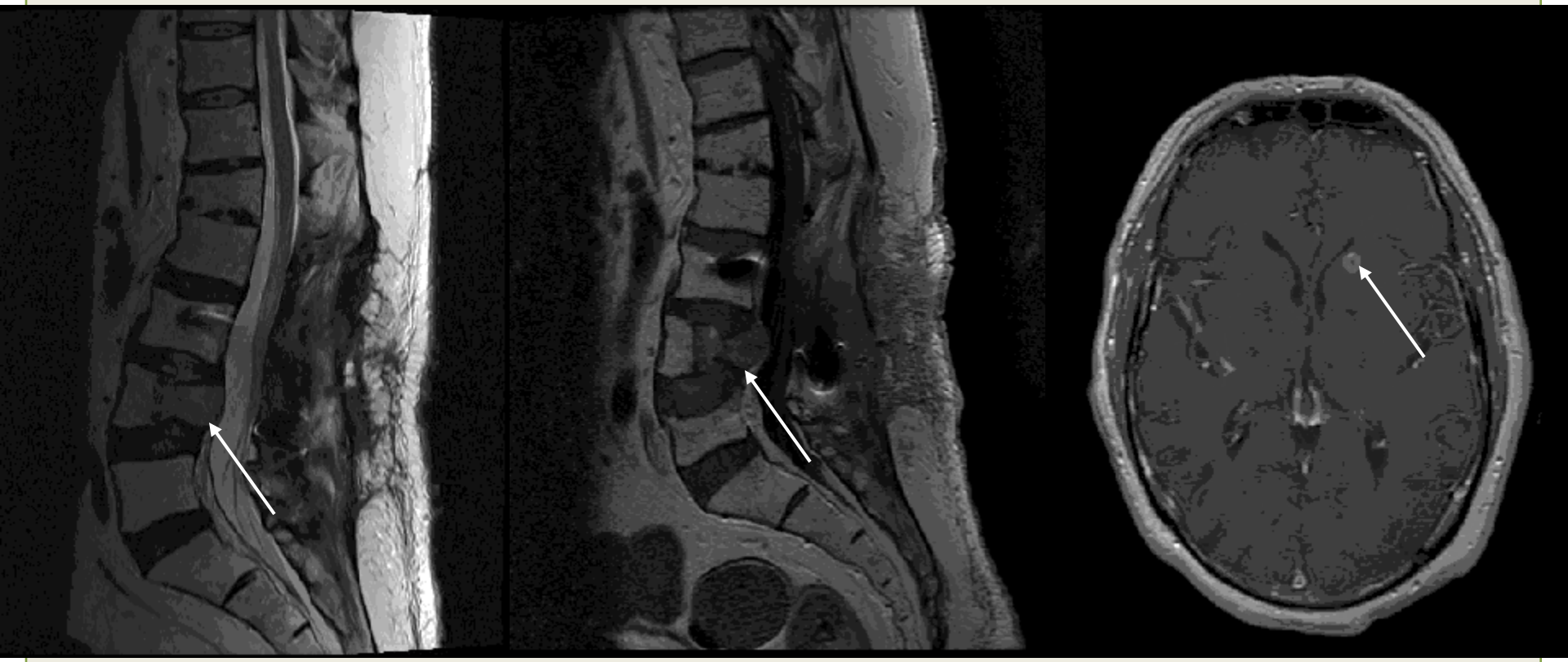
Treatment Delivery (Matching of pCT with CBCT and treatment table adjustments)

Importance of Multimodal Imaging

- Planning CT images essential for dose calculation and positioning for treatment
- Do not show the location of tumor or spinal cord
- Need MR imaging registered to CT imaging to show tumor and normal anatomy



Adjuvant Spinal Radiosurgery After Open Surgery



Pre-Radiosurgery

3 Mos After with Pain Control

Now With Brain Mets

Summary

- Frameless image-guided spinal radiosurgery is an important tool in the treatment of spinal tumors.
- Pain and tumor control is well documented in patients after spinal radiosurgery for spinal metastases.
- Spinal radiosurgery not indicated for all pts with spinal tumors.
- Mutimodal imaging is necessary for understanding of the anatomical relationship of the tumor to spinal cord.
- Patient immobilization and positioning is necessary for precise targeting and dosing of spinal tumor.
- Matching of CBCT to planning CT images can improve radiosurgery accuracy.
- Spinal radiosurgery may be used as part of multimodal treatment after surgical resection of spinal tumors for residual or progressive lesions.

RTOG 0631-Phase II/III Study of Image-Guided Radiosurgery/SBRT For Localized Spine Metastasis

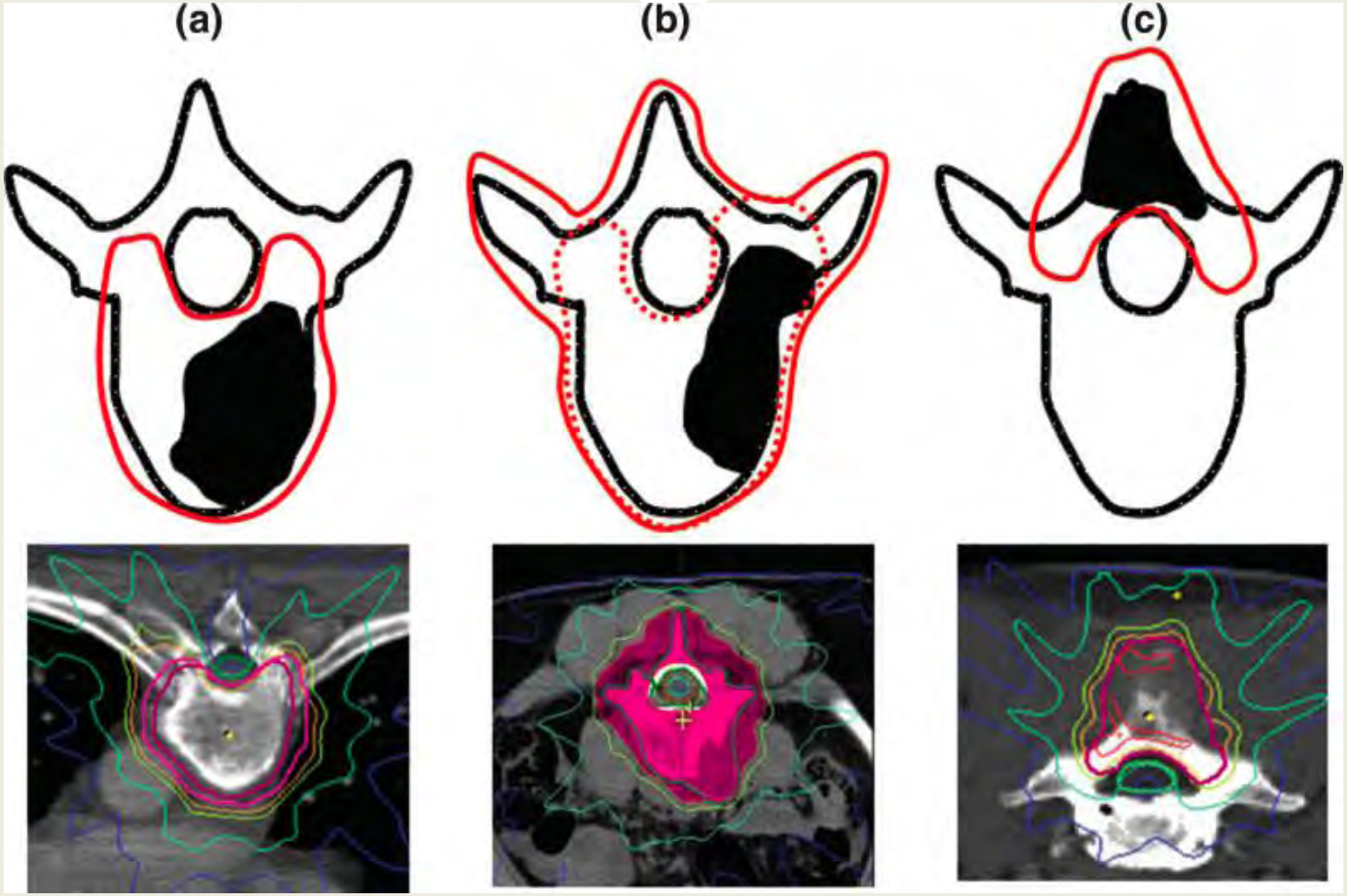
Phase II is efficacy of pain control at 3 mos.

49 pts.

240 pts.

Hypothesis: Spinal radiosurgery will result in improvement of pain relief at 3 months in 40% of patients treated in comparison to EBRT (numerical rating pain scale, NRPS).

Target Delineation and Treatment Volume



-90% target volume txed with 16 Gy prescribed dose

Acknowledgment

- Cynthia Anderson, M.D. - Assistant Professor of Emory Radiation Oncology
- Wally Curran, M.D.-Executive Director, Winship Cancer Institute, Professor and Chair of Radiation Oncology
- Ian Crocker, M.D.- Professor of Emory Radiation Oncology
- Hui-Kuo Shu, M.D.-Associate Professor of Emory Radiation Oncology
- Anthony Waller- Research Assoc., Emory Radiation Oncology
- Dane Peterson, COO, Emory Univ. Midtown Hospital
- Marisol Cintron, Annie Mullins, Theresa Huffma, and Vince Dollard, Emory University

THANKS!

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