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Automatic Segmentation of Intradural Spinal Tumors in Post-Contrast T1-Weighted MRI Scans

Golnaz Moallem, Ph.D.
Postdoc Research Fellow, PIMed Lab
Department of Radiology, Stanford School of Medicine

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Outlines

Introduction

- What are intradural spinal tumors?

Data

Methods

- Preprocessing
- 3D U-net segmentation model
- Model Details and data statistics

Results

Challenges and Next Steps

Introduction: What are Intradural Spinal Tumors?

Spinal Tumors

- Large heterogenous group of abnormal mass of tissue affecting the spinal cord
- Developed within or near the spinal cord
  - **Intradural**: growth within the dura of the spinal cord
    - Intramedullary
    - Extramedullary
  - Extradural: mass within the spinal column
- Primary or secondary
- Malignant or Benign
- Ramifications: pain, neurological damage, loss of mobility, etc.

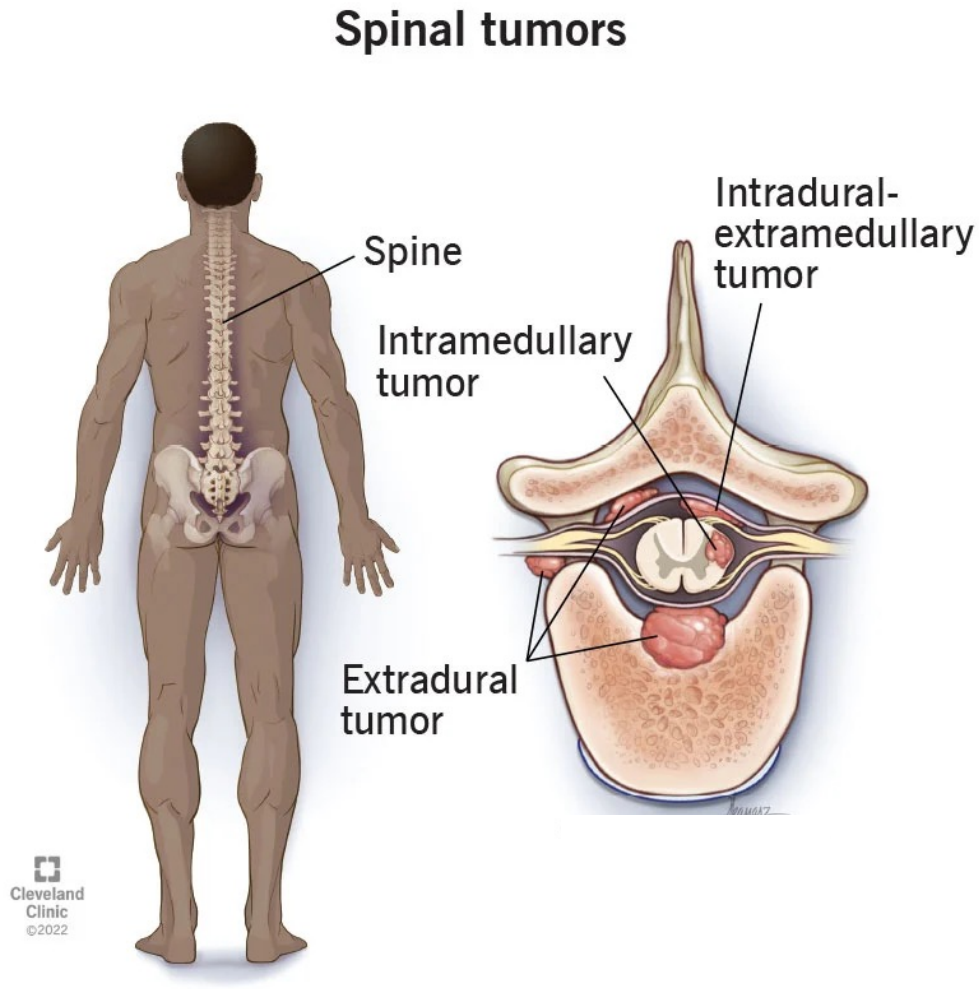
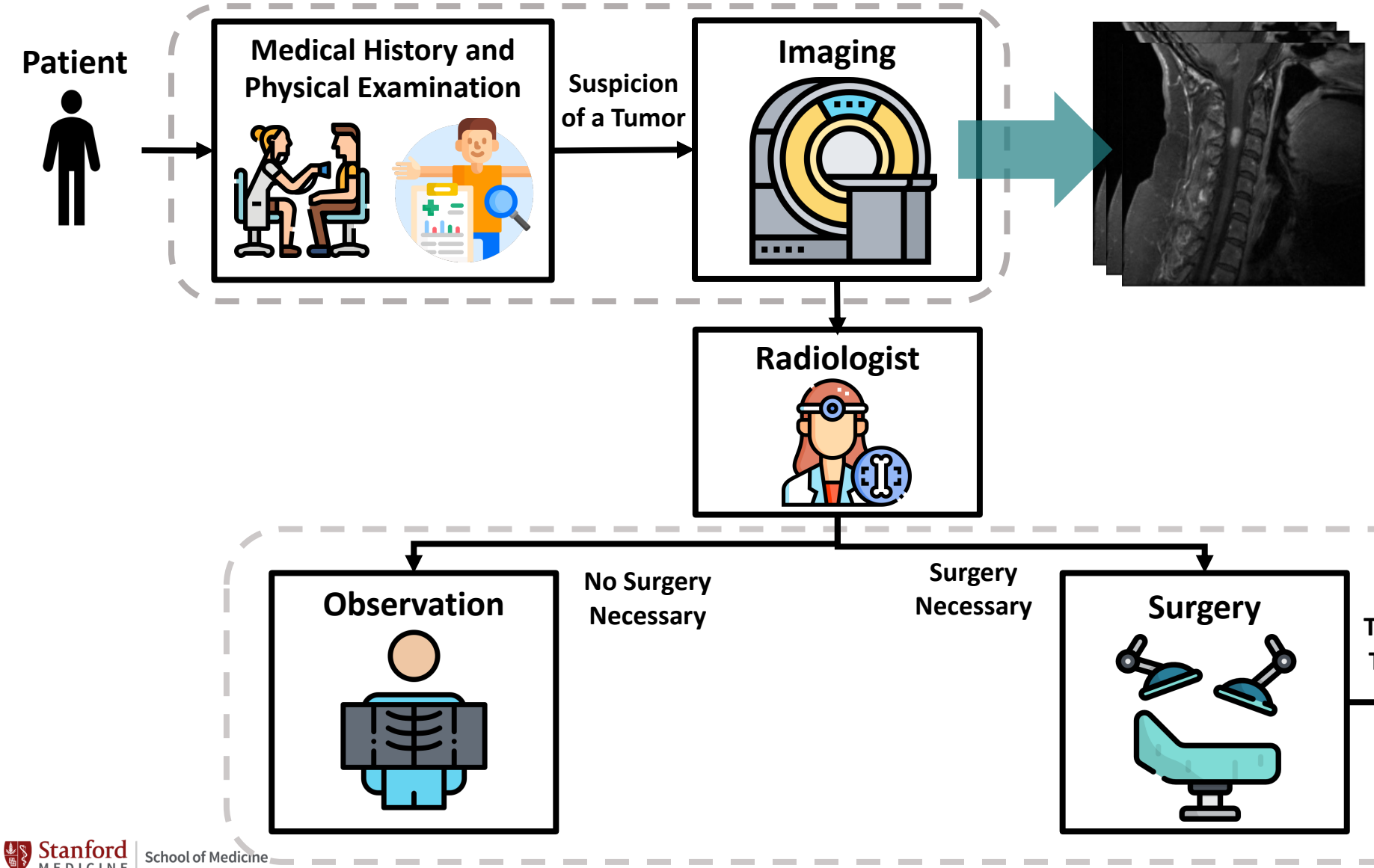


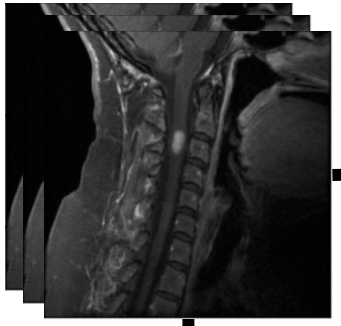
Photo from: my.clevelandclinic.org

Intradural Spinal Tumor Treatment Workflow



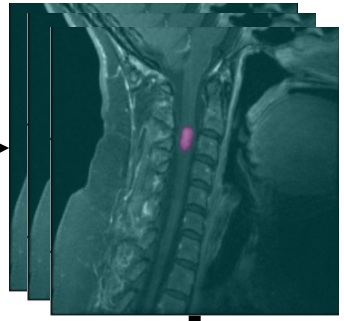
Photos from: www.flaticon.com

Intradural Spinal Tumor Treatment Workflow

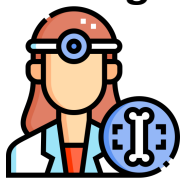


Diagnosis Supplemental Tool

Automatic Segmentation Model



Radiologist



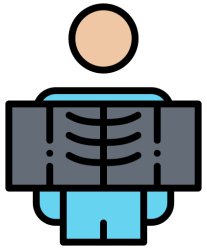
Pathological Tumor Type Detection Tool

Meningioma

No Surgery Necessary

Surgery Necessary

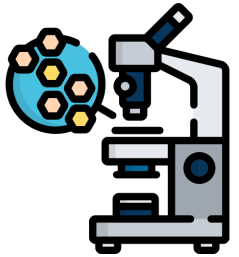
Observation



Surgery

Type of Tumor

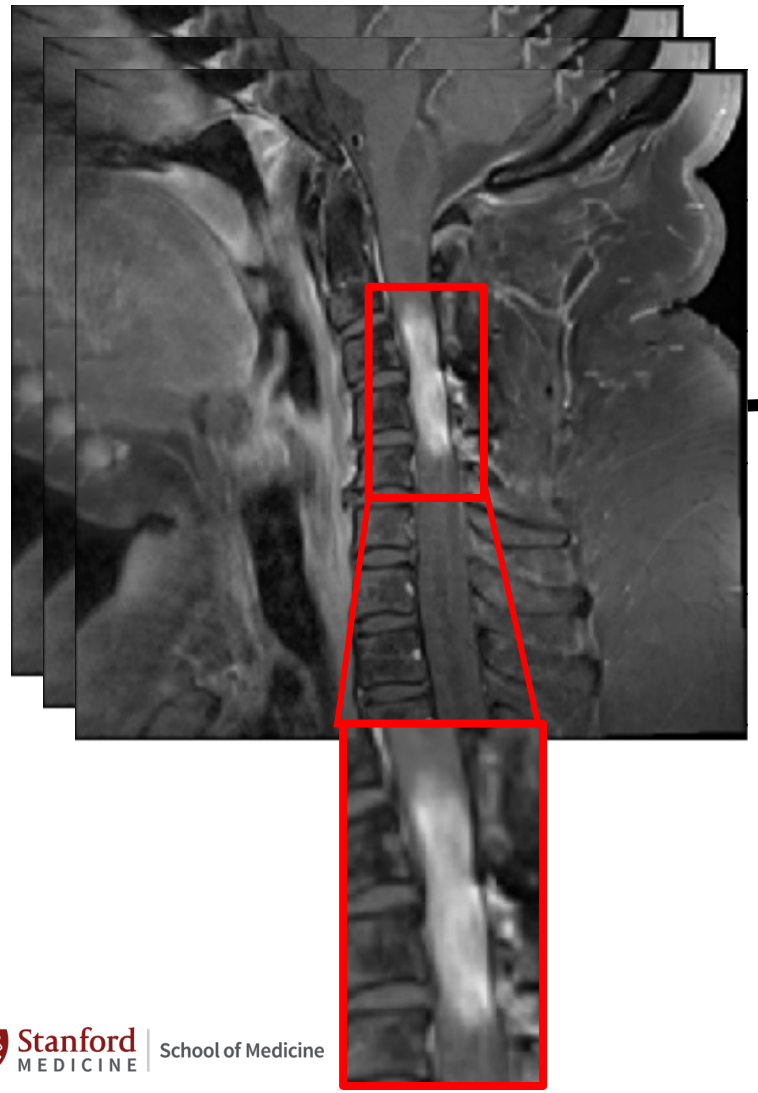
Pathology



Photos from: www.flaticon.com

Automatic Segmentation Model

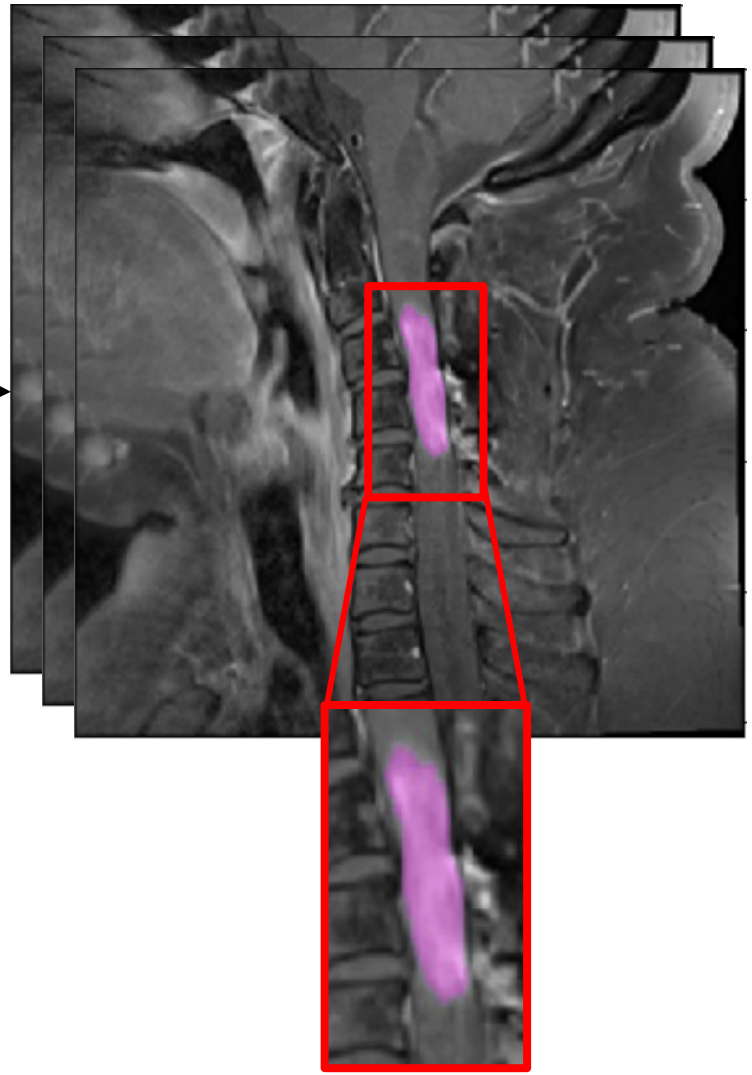
Post-Contrast T1-Weighted Spinal MRI Scan



Tumor Detection Supplemental Tool

Automatic Segmentation Model

Segmented Tumor



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Data

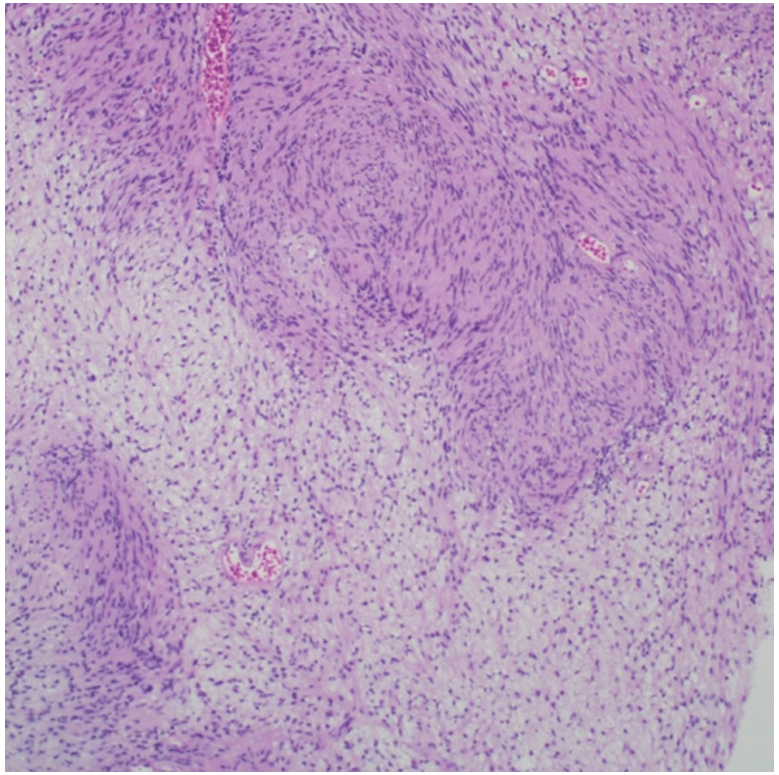
Data

- **58 intradural spinal tumor cases** from the Stanford University hospital database
  - Surgical cases; pathology images available
  - Post-contrast T1-weighted MRI scans
  - Multiple manufacturers

Sagittal View

Axial View

Pathology Slide



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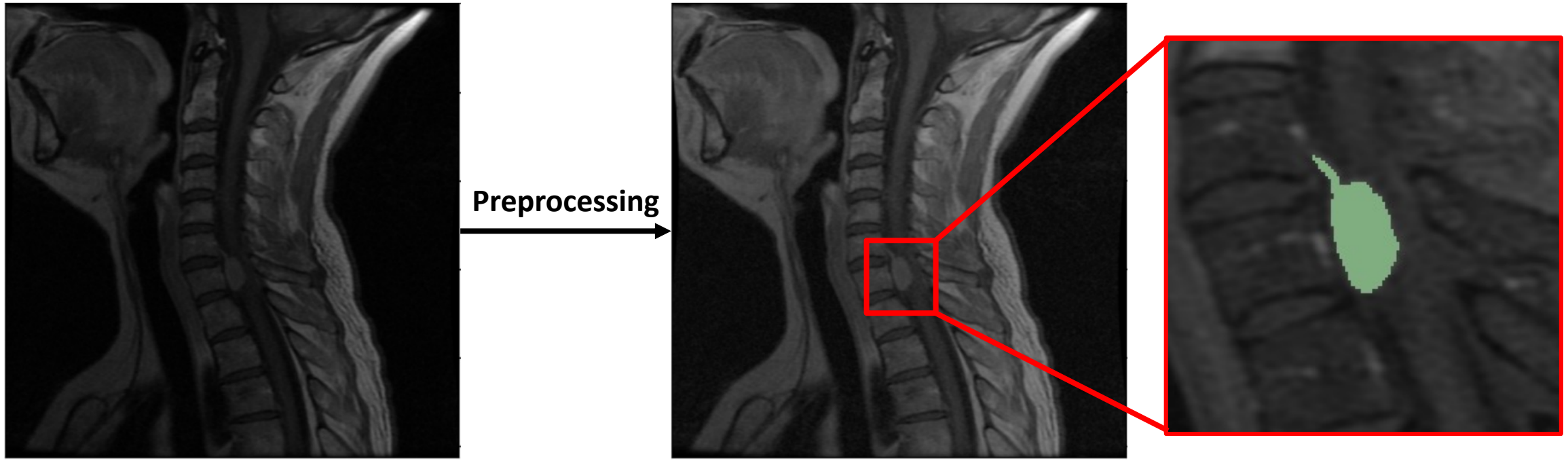
Pathology slide from: https://pubs.rsna.org/doi/full/10.1148/rg.2019180200

Methods

Methods: Preprocessing

Preprocessing steps using MONAI Library:

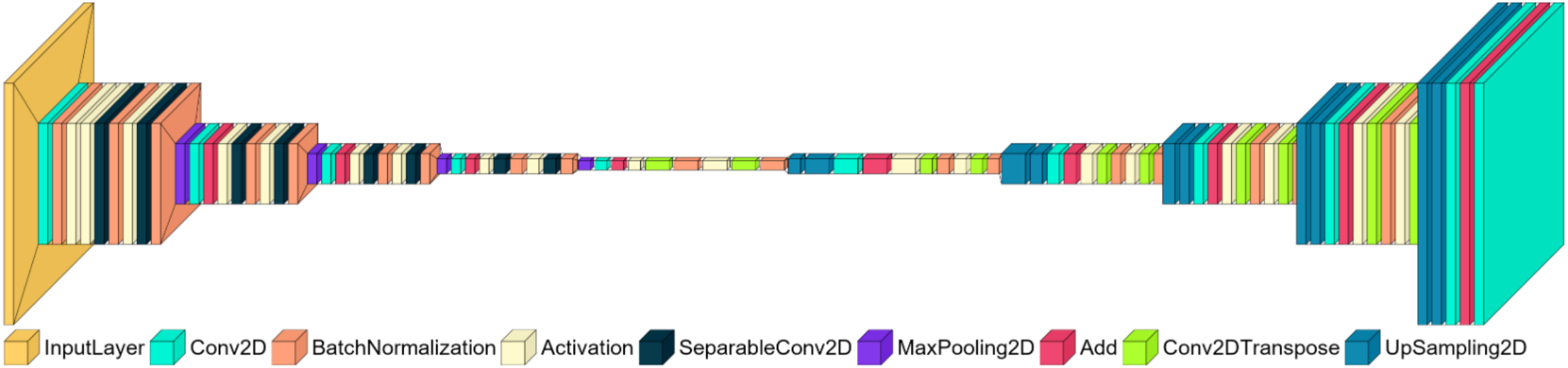
1. Adjust contrast by gamma correction ($x = (\frac{x - min}{\max - min})^{gamma} * (\max - \min) + min$)
2. Bias field correction [1]
3. Scale intensity values ($x = \frac{x - min}{\max - min}$)
4. Resize
5. Spatial Padding



[1]: Van Leemput, Koen, et al. "Automated model-based tissue classification of MR images of the brain." *IEEE transactions on medical imaging* 18.10 (1999): 897-908.

Methods: U-Net Model

3D U-Net Segmentation Model:



Methods: Model Details and Data Statistics

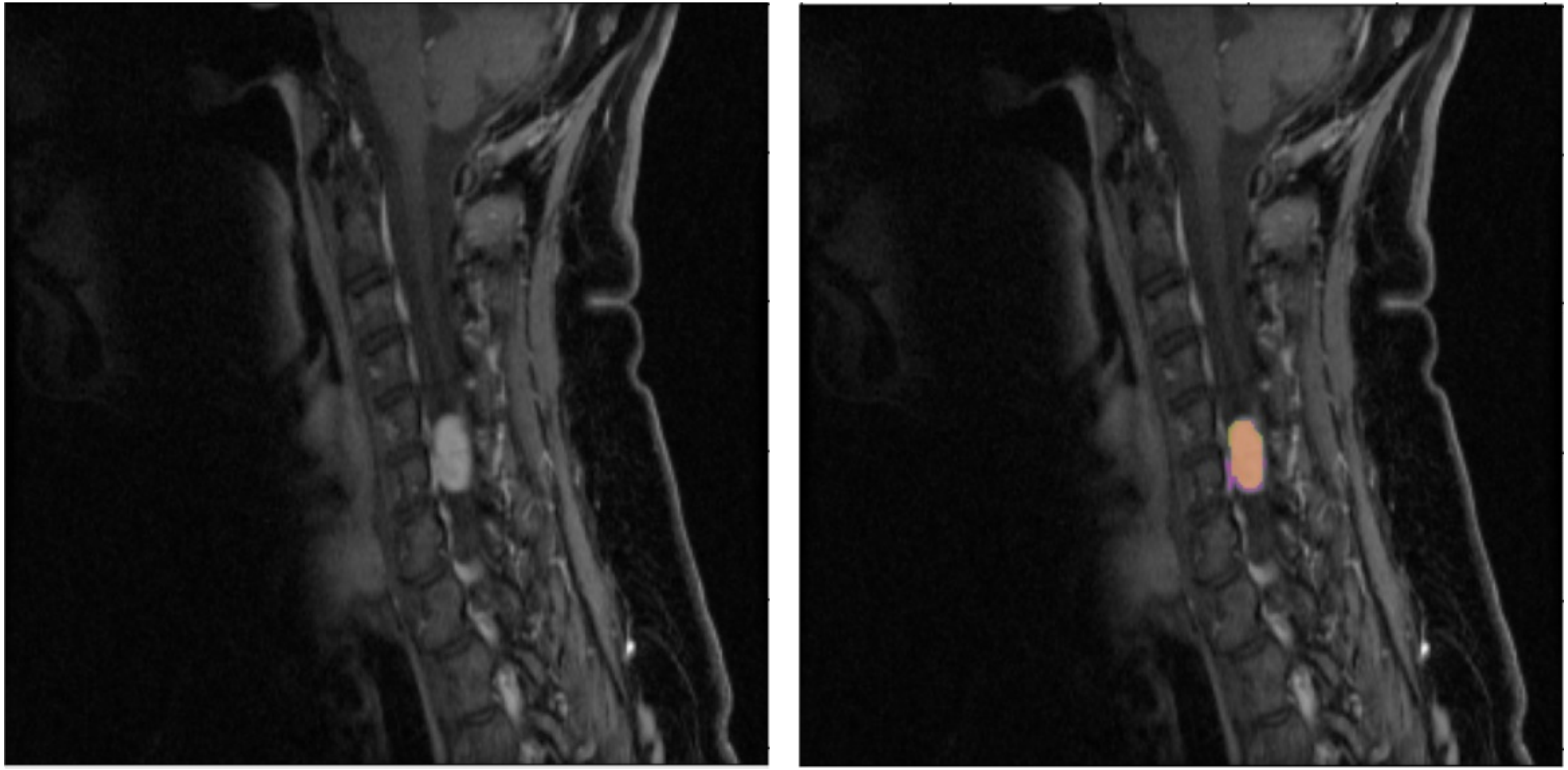
Dataset	Training set	Testing set
Count	43 (74%)	15(26%)

Parameters		Values
U-Net Model	Sequence of channels	$(16, 32, 64, 128, 256)$
	Kernel and up-kernel sizes	$3\times3\times3$
	Strides	$(2, 2, 2, 2)$
Training Hyperparameters	Loss function	$DiceLoss$
	No. of epochs	400

Results

Segmentation Example

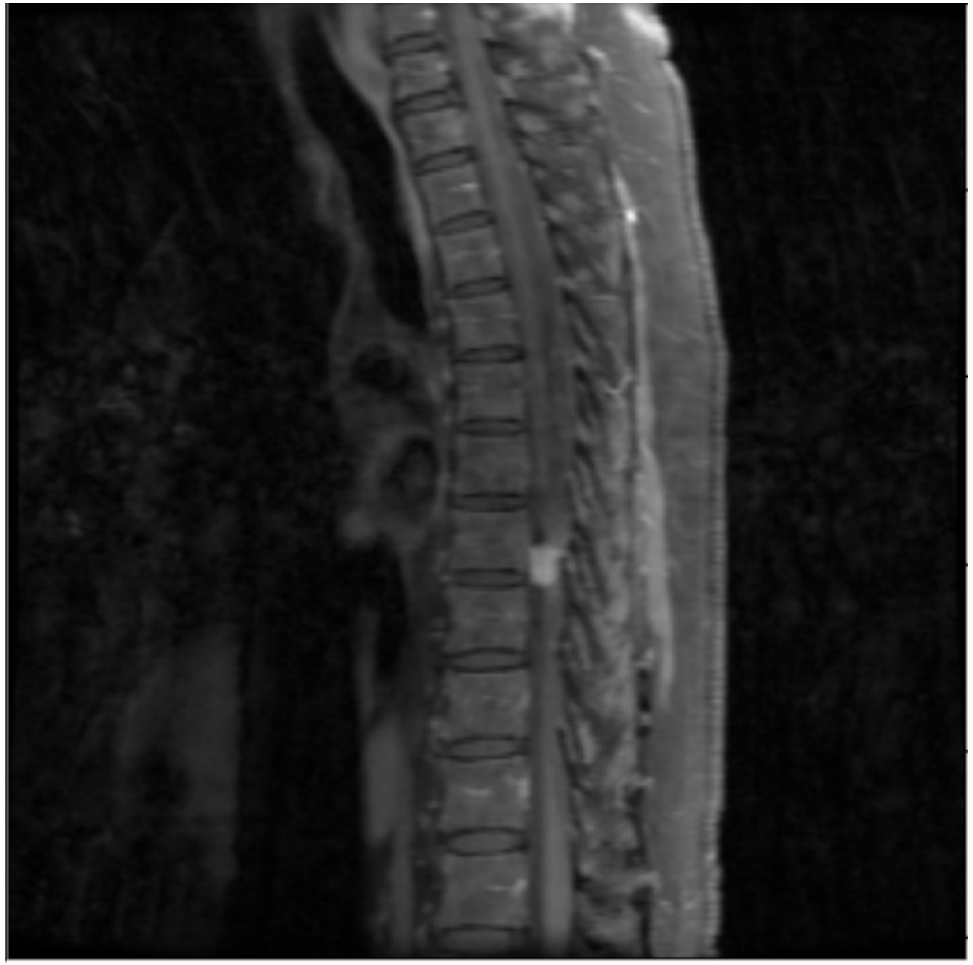
Prediction Annotation



DICE = 0.9

Segmentation Example

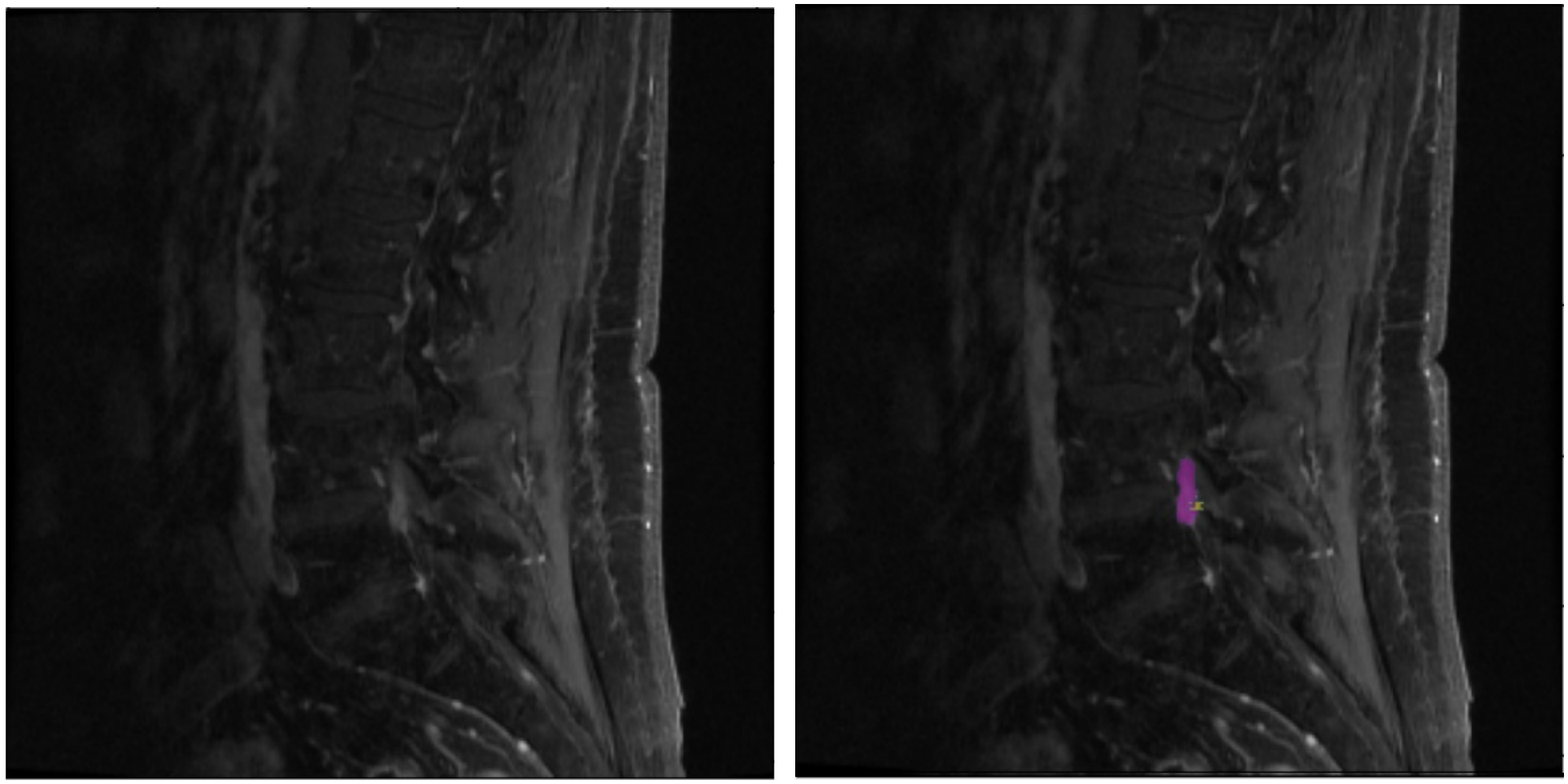
Prediction Annotation



DICE = 0.64

Segmentation Example

Prediction Annotation



DICE = 0.45

Segmentation Example

Prediction Annotation

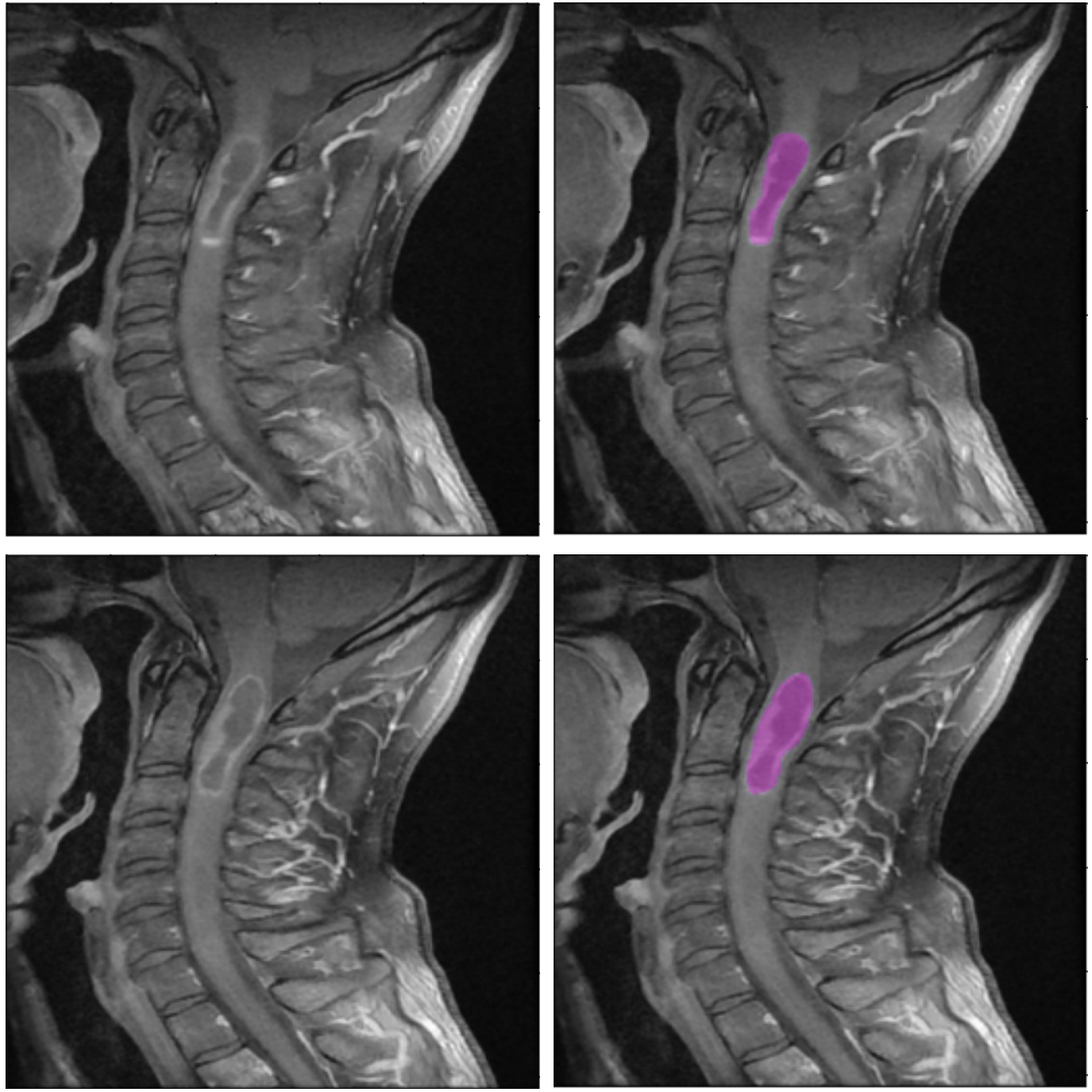
DICE = 0.74

Preliminary Results

K-Fold Cross Validation (K = 4)				
Fold	**No. of Cases**	**Patient-level Sensitivity**	**Overall Mean DICE**	**True Positive Mean DICE**
Fold 1	15 cases	11 out of 15 (73%)	0.35 ± 0.27	0.47 ± 0.21
Fold 2	15 cases	12 out of 15 (80%)	0.42 ± 0.3	0.52 ± 0.24
Fold 3	15 cases	8 out of 15 (53%)	0.18 ± 0.24	0.33 ± 0.2
Fold 4	13 cases	8 out of 13 (62%)	0.36 ± 0.33	0.58 ± 0.23
Average		**66.5%**	$\mathbf{0.33 \pm 0.27}$	$\mathbf{0.48 \pm 0.22}$

Challenging Cases

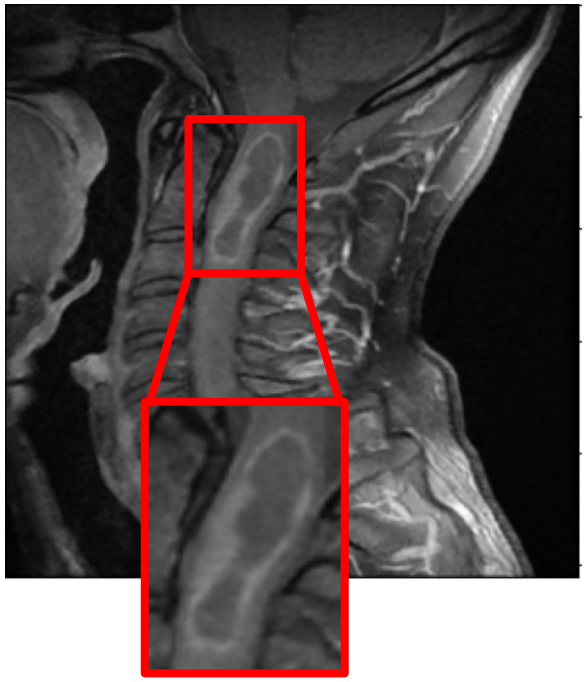
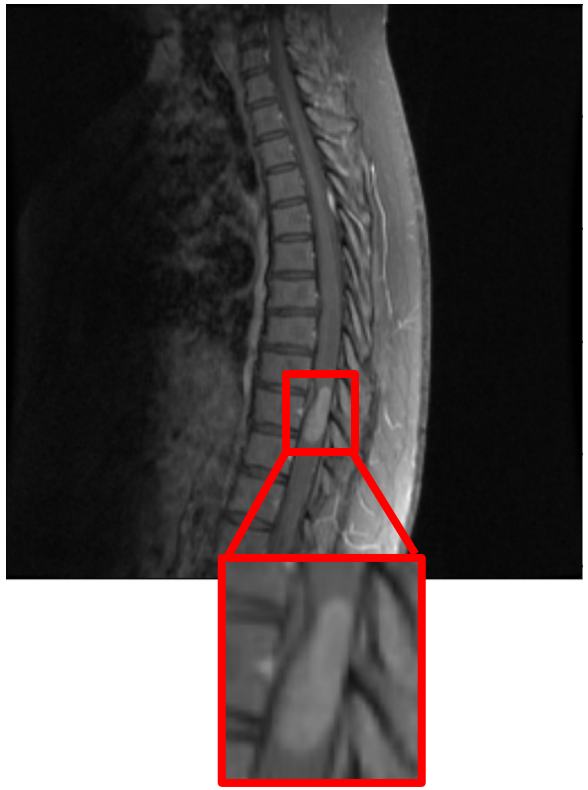
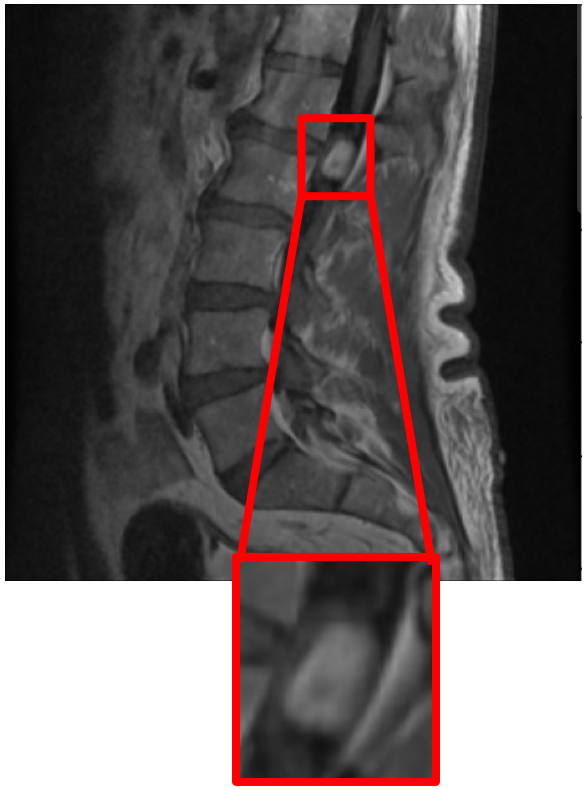
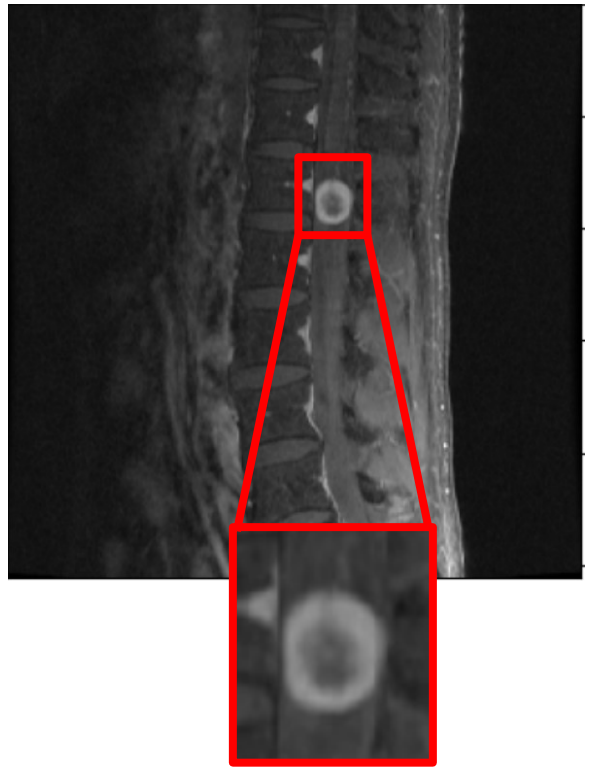
- Heterogenous appearance (enhancing rim, necrosis inside)
- This type of tumor may not be represented in the training set



Challenges and Next Steps

Challenges

- Limited annotated data
- Heterogenous tumor shapes and types
- Variation in the field of view

Next Steps

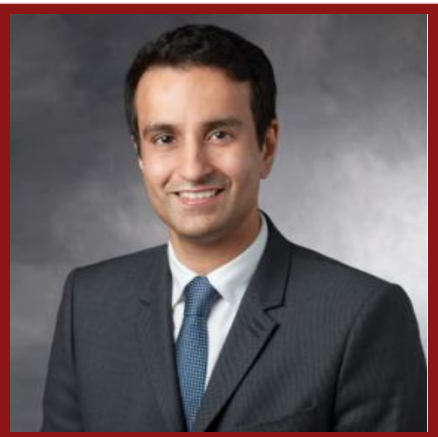
- Expand the training set
- Improve the preprocessing step
- Incorporate axial view of MRI Scan in training the model
- Try other segmentation approaches
- Develop a deep learning model for sub-type classification of the tumors

Conclusion

- An AI-powered intradural spinal tumor diagnosis tool presented to assist the radiologist/surgeon in identifying these tumors in MRI scans
- For this purpose, an automated segmentation model proposed for segmenting intradural spinal tumors in post-contrast T1-weighted MRI scans
- Preliminary results for this segmentation model demonstrated on a cohort of surgical intradural tumor cases

Thank You!

Mirabela Rusu, PhD
Assistant Professor Of Radiology and, By Courtesy, Of Urology



Atman Desai, MD
Spine Neurosurgeon
Clinical Associate Professor, Neurosurgery

Hammad Ghanchi, DO
Clinical Instructor, Neurosurgery

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