Voxel-based analysis unveils regional dose differences associated with radiation-induced morbidity in head and neck cancer patients

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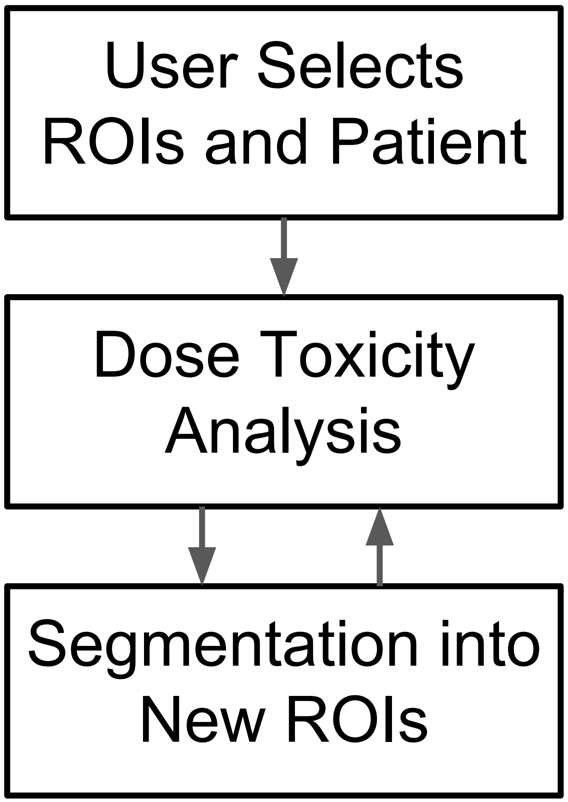
Project Summary

- Develop a UI for dose toxicity analysis
- Connect user with existing analysis and segmentation tools
- Visualize 3D objects and analysis output - dose volume histograms (DVH)
- Run analysis on and render newly segmented 3D objects



Paper Selection

Paper:

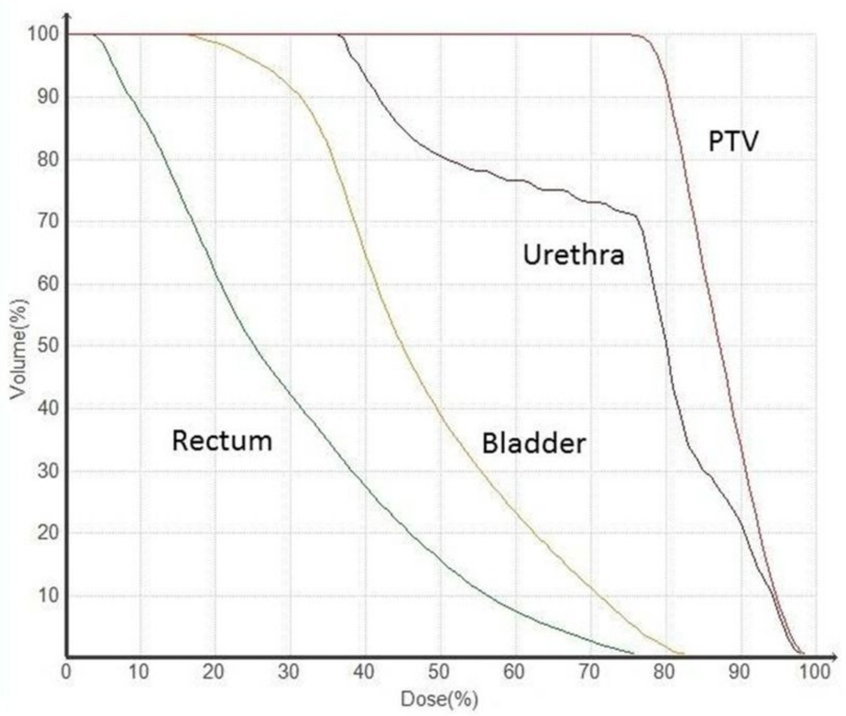
- Demonstrates efficacy of local dose toxicity analysis for radiation therapy (RT) on head and neck (HN) structures vs. whole organ analysis

Our project:

- Allow user to easily visualize and perform dose toxicity analysis on ROIs
- Allow user to segment ROIs and perform dose toxicity analysis on new regions

Problem - Dose Toxicity Analysis is Outdated

- Only concerned with organ at risk
- Especially inadequate for HN structures due to their small size and complexity
- Voxel-based (VB) approaches have demonstrated utility in prostate, bladder, and thoracic cancers
- HN structures pose unique challenges for VB approach

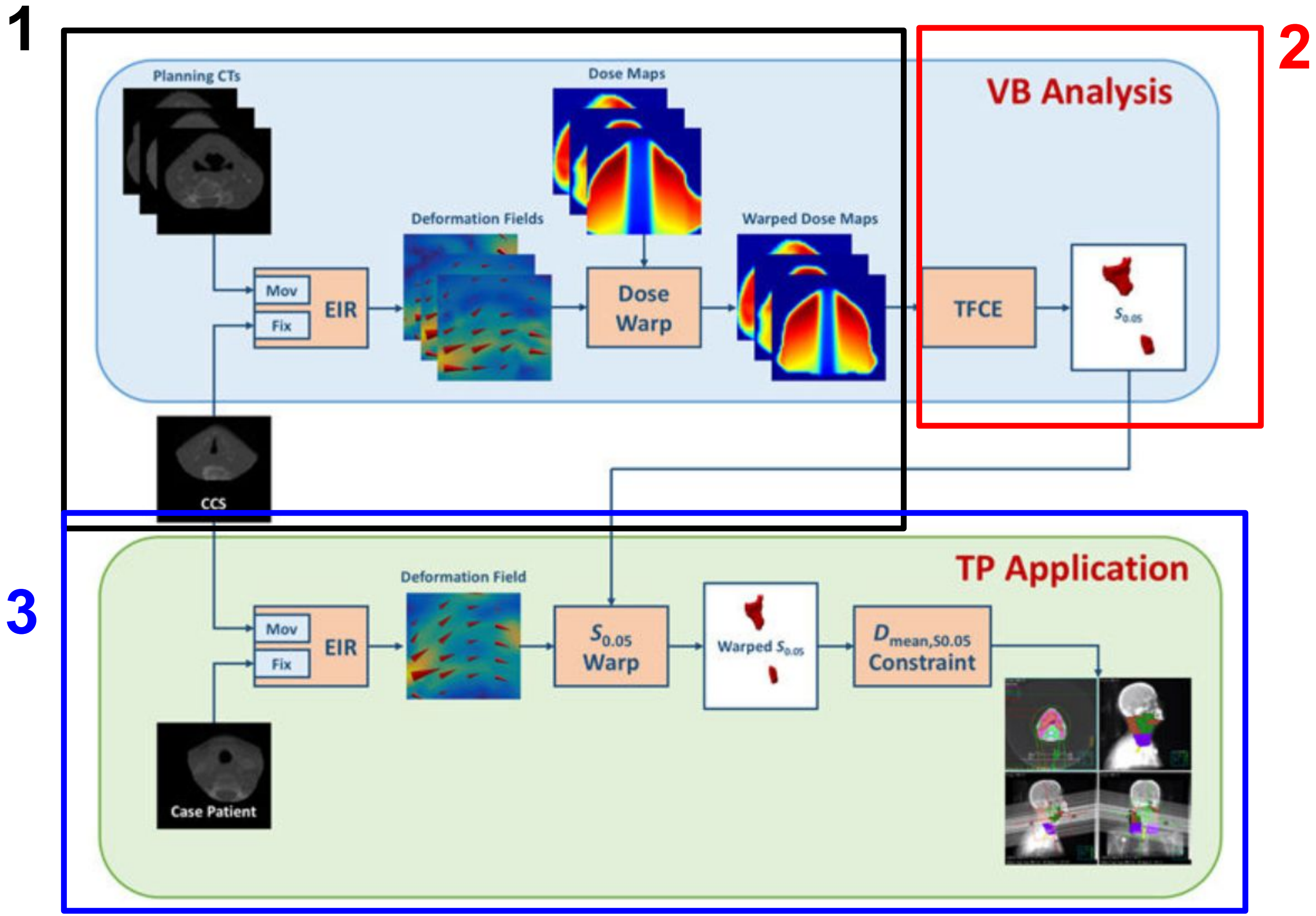


Key Finding

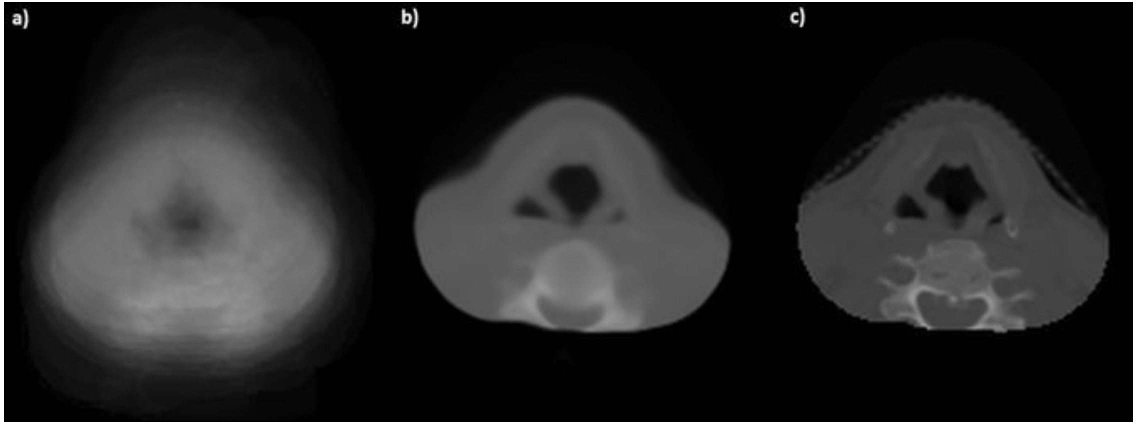
1. Demonstration that VB method can be applied to cancers of the HN
2. Identification of two regions associated with higher risk of radiation-induced acute dysphagia (RIAD)
    a. cricopharyngeus muscle
    b. cervical esophagus

Methods

100 subjects



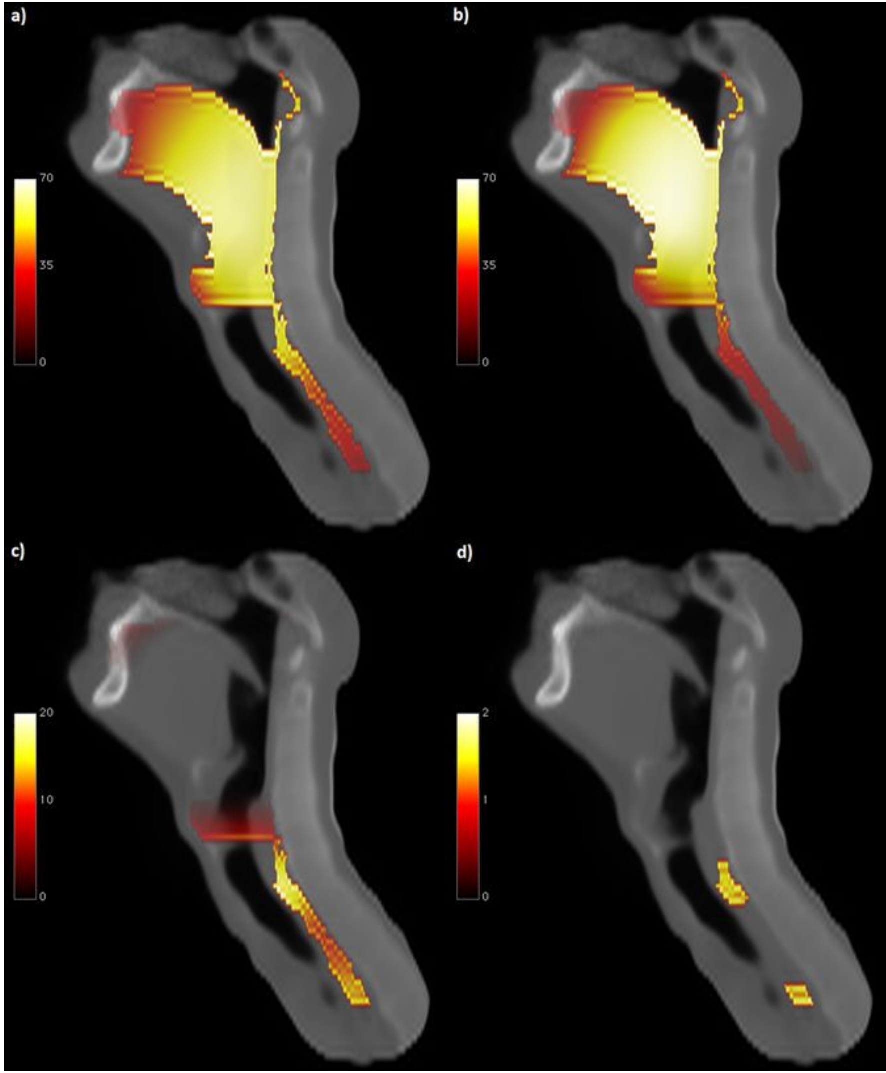
EIR

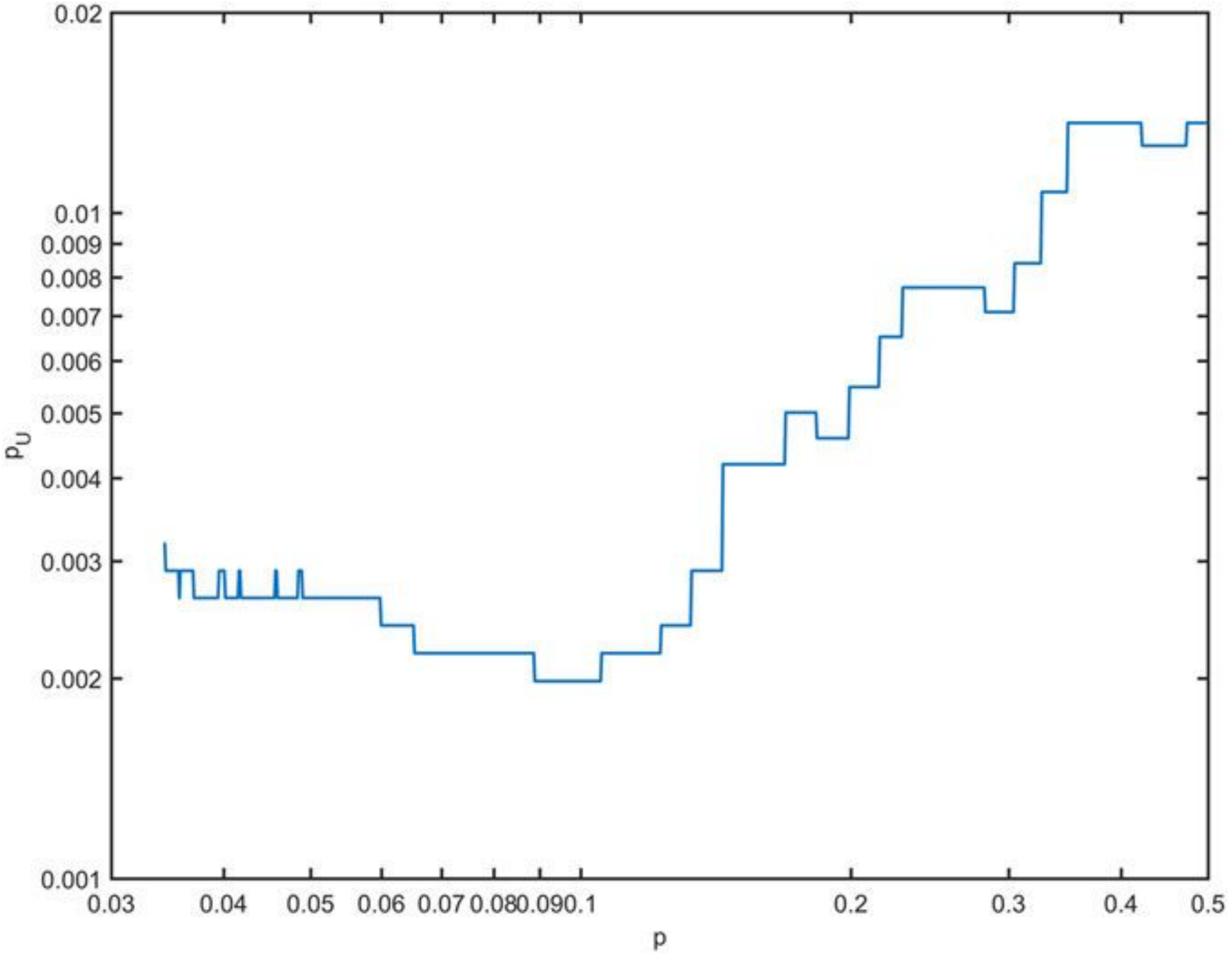


- Register CT scans to common coordinate system (CCS), determine deformation fields, warp dose maps to CCS
- Geometrically Robust, accurate dose warping
- Dice, modified Hausdorff distance, and dose-organ overlap scores: p value < 10^-4

Statistical Analysis

1. Confirmation of dose differences between patient with and without RIAD
2. Threshold-free cluster enhancement (TFCE) identifies voxel clusters with significant dose differences
3. Determine $S0.05$ region
   a. 5.1 cm^3
   b. p = 0.003
   c. AUC = 81%





0.02
0.01
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0.006
0.005
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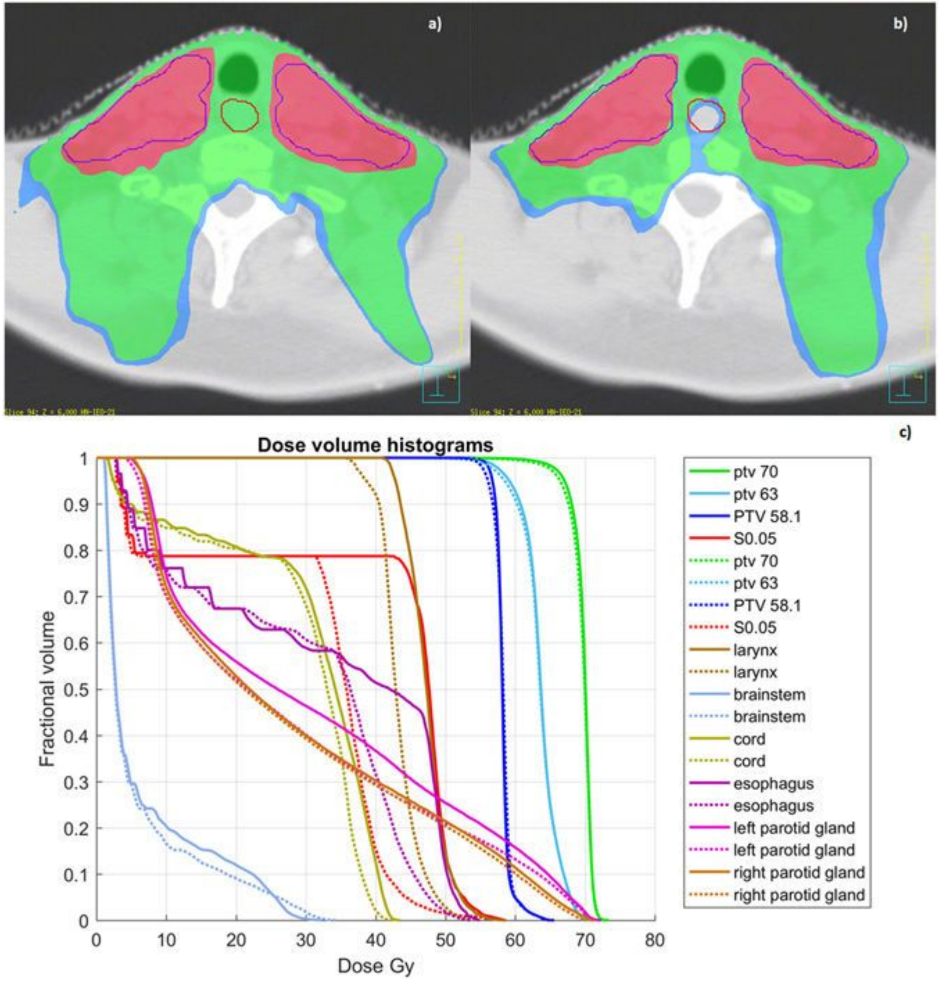
p

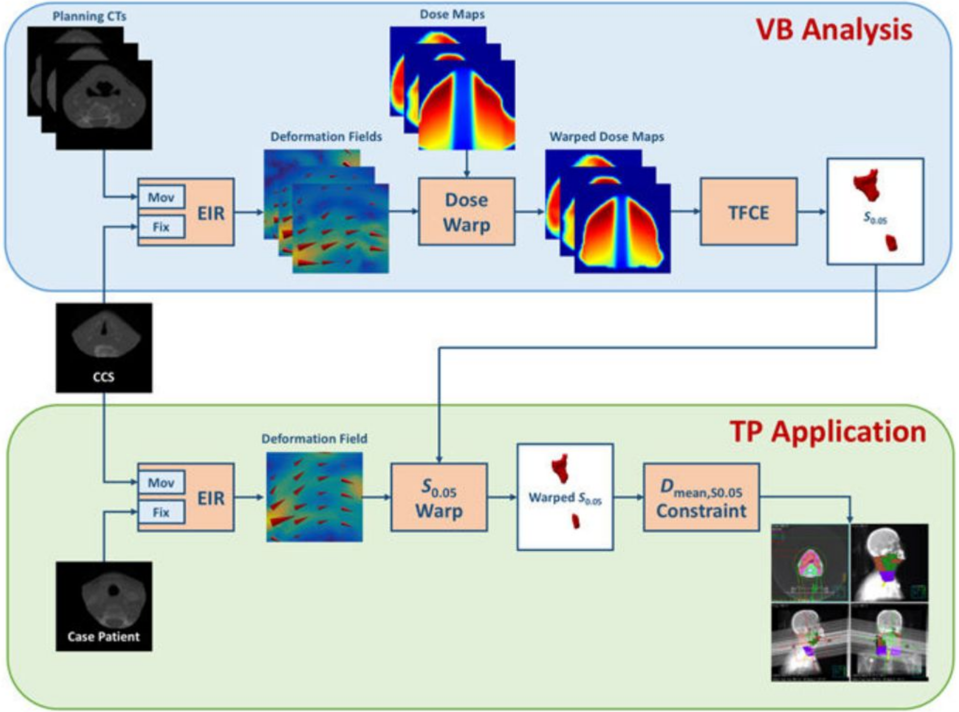
Treatment Planning

- Oropharyngeal cancer patient
- Warp $S0.05$ region in CCS to patient CT CS
- Mark $S0.05$ region as avoid
  - First quartile of $S0.05$ dose
- Validate that new treatment plan (TP)



Discussion

- Demonstrate applicability of VB method to HN RT
- Use of validated algorithms to address inherent limitations of VB method in statistical analysis and image registration
- Identified voxel clusters were associated with muscles known to be involved with dysphagia
- VB method can be employed in future RT for HN



Assessment

- Authors overcame traditional issues associated with HN structures during registration and dose toxicity analysis
- Dysphagia is a common side effect of HN RT
    - 29,000 new cases of Laryngeal and Pharyngeal cancer every year
- Potential for application to other HN cancer RTs

Assessment

Pros	Cons
Validation techniques and algorithms well cited	1st quartile constraint is arbitrary
VB method eliminates human bias and variability	Claims generalizability but only investigates RIAD
TP required one iteration for significant dose reduction	Not translated to clinic yet
Clearly written	

Next steps

- Test VB methodology on new side effects
- Refine treatment plan - what is appropriate dose constraint for sensitive regions?
- Clinical Validation

Implications for Our Project

- Validates motivation for more localized dose toxicity analysis
- Add modules to UI
  - Comparison to a reference treatment
  - Consult mentors on segmentation tools and their utility

References

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Extra Slides

EIR Verification

	Dice		MHD (mm)		DOO	
	pre	**post**	**pre**	**post**	**pre**	**post**
Median	0.67	0.80	2.31	1.22	0.51	0.66
Range	[0.03,0.83]	[0.59,0.82]	[0.53,24.13]	[0.78,4.46]	[0.02,0.68]	[0.46,0.76]
p-value§	$<10^{-5}$		$<10^{-4}$		$<10^{-6}$	

Abbreviations: MHD, Modified Housdorff Distance; DOO, Dose-Organ Overlap. § *p*-values express the significance of the interpatient match improvement at Wilcoxon signed rank test.