

# Synthetic and estimated tissue displacement in high-grade glioma

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University of Oslo

ADF



# Goal

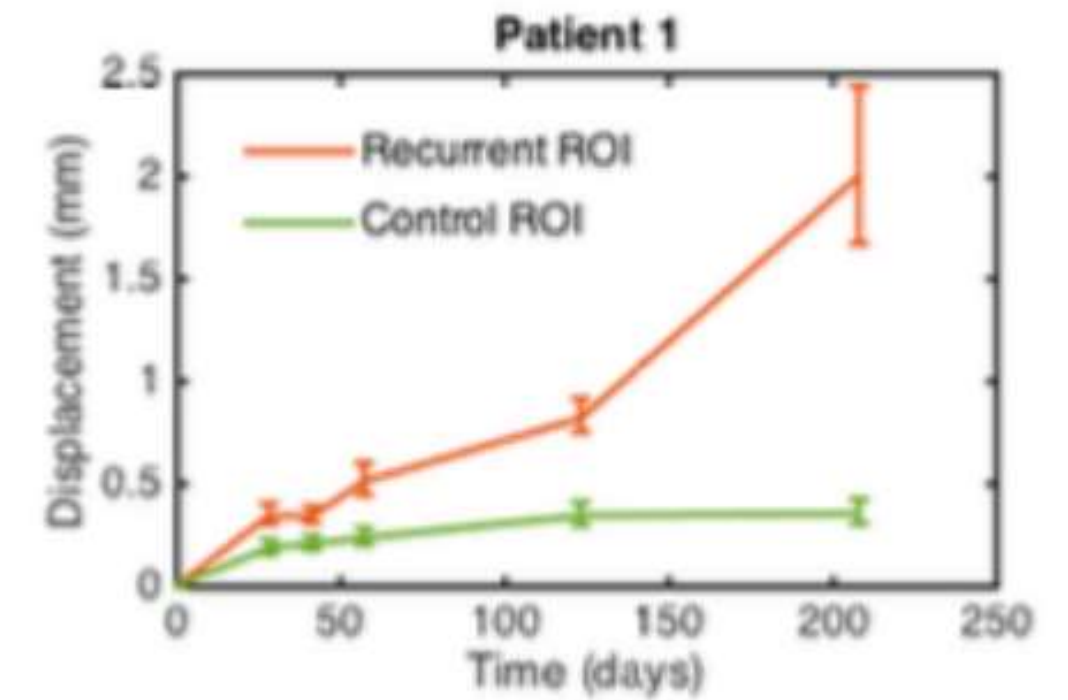
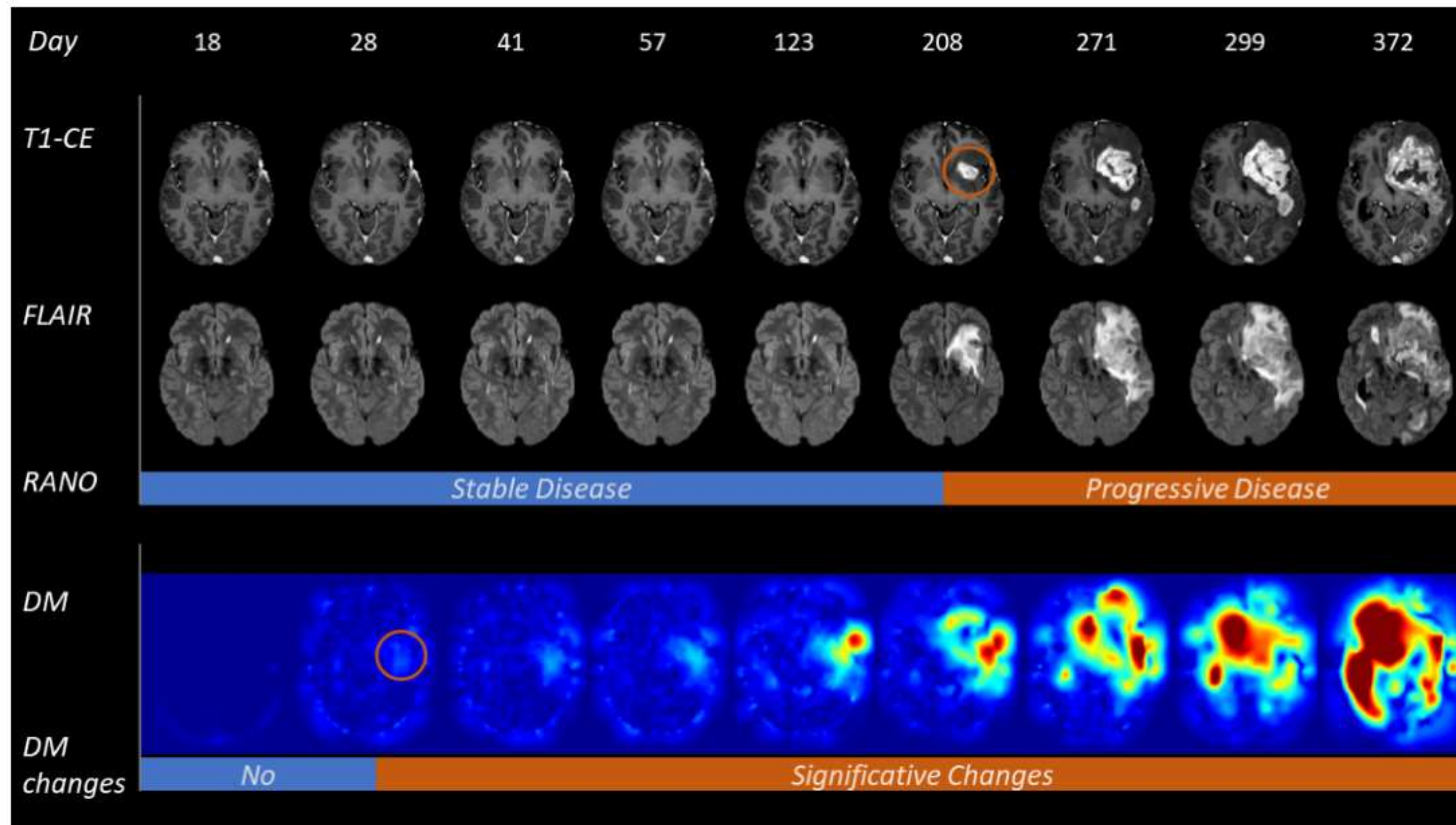
- Present the current state of my second publication
- Plans for the next publication

Suggestions are welcome!

# Background

Tissue displacement in glioblastoma from non-rigid registration

# Displacement maps in glioblastoma

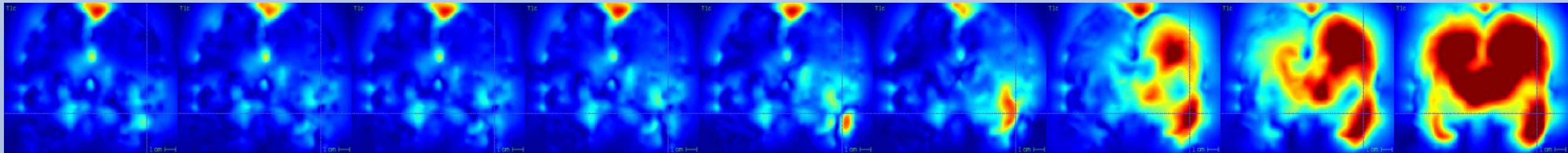
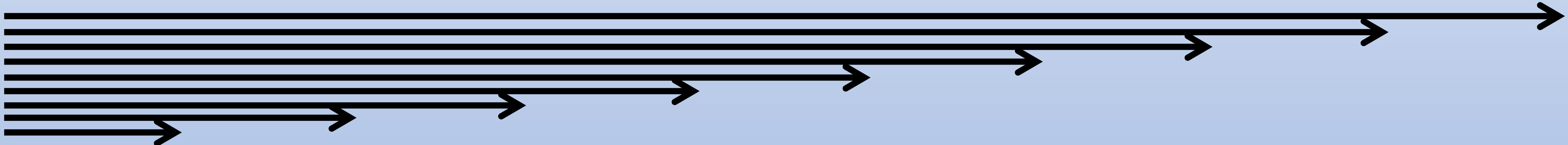
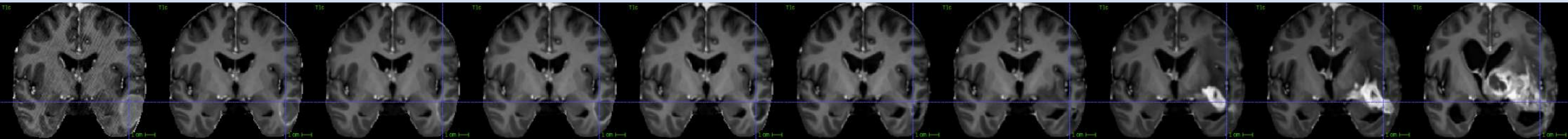


Elies Fuster-Garcia 2019/2020

**Fig. 2.** Longitudinal evolution of Patient 1 from day 18 after starting radiochemotherapy treatment to day 372. According to RANO criteria tumor progression started on day 208, however displacement maps (DM) show significant deformations already at day 28.



Day





Days, interval

18

10

13

16

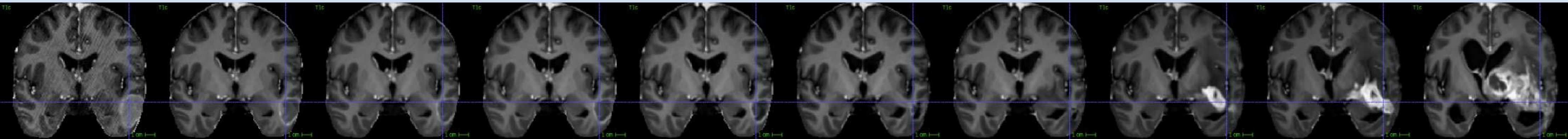
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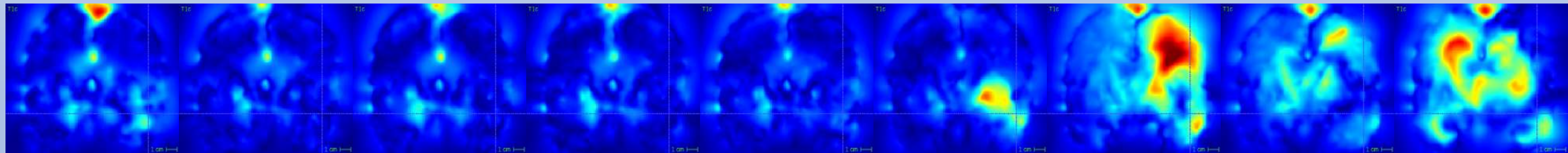
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# Challenges

- How accurate are estimated displacements in (traditionally) clinically important regions?
  - Contrast-enhancement
  - Necrosis
  - Edema
- Can coregistration estimate displacement better under specific conditions?
  - Amount of true displacement in *mm*
  - Amount of growth infiltration
  - Irregularity of tumoral growth displacements

# 2nd publication

Evaluating non-rigid registration for tumor growth characterization by creating synthetic displacements

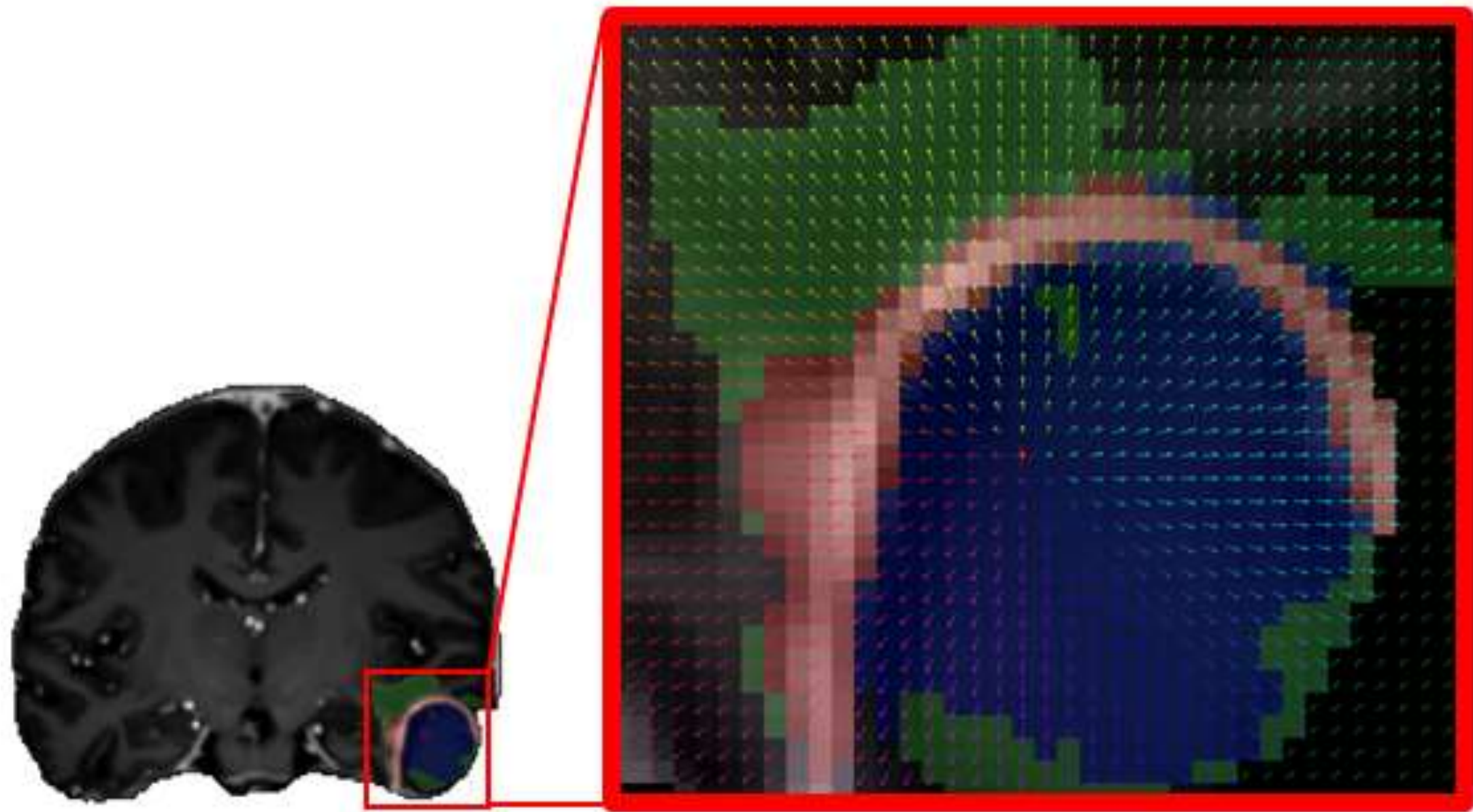


# Outline

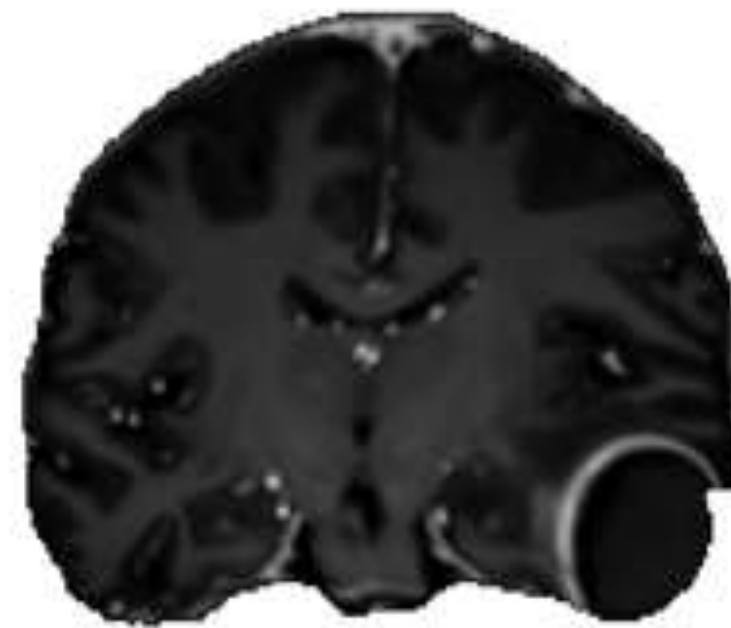
(\*)  
MI=Mutual Information  
CC=Cross Correlation

- Created a simple radial growth model for generating synthetic displacements with input parameters for (maximum) tissue displacement, tumor infiltration and growth irregularity.
- Tested five non-rigid registration methods by estimating model generated displacements (ANTs SyN with MI and CC \*, Farneback, ILK, TV-L1).
- Hypothesis: We expect the five methods to perform equally good in contrast enhanced, necrotic and edematous regions for the following different simulated conditions:
  - Low (3-) and high (8-*mm*) maximum tissue displacement.
  - Low and high infiltration parameter setting.
  - No, intermediate and high growth irregularity.

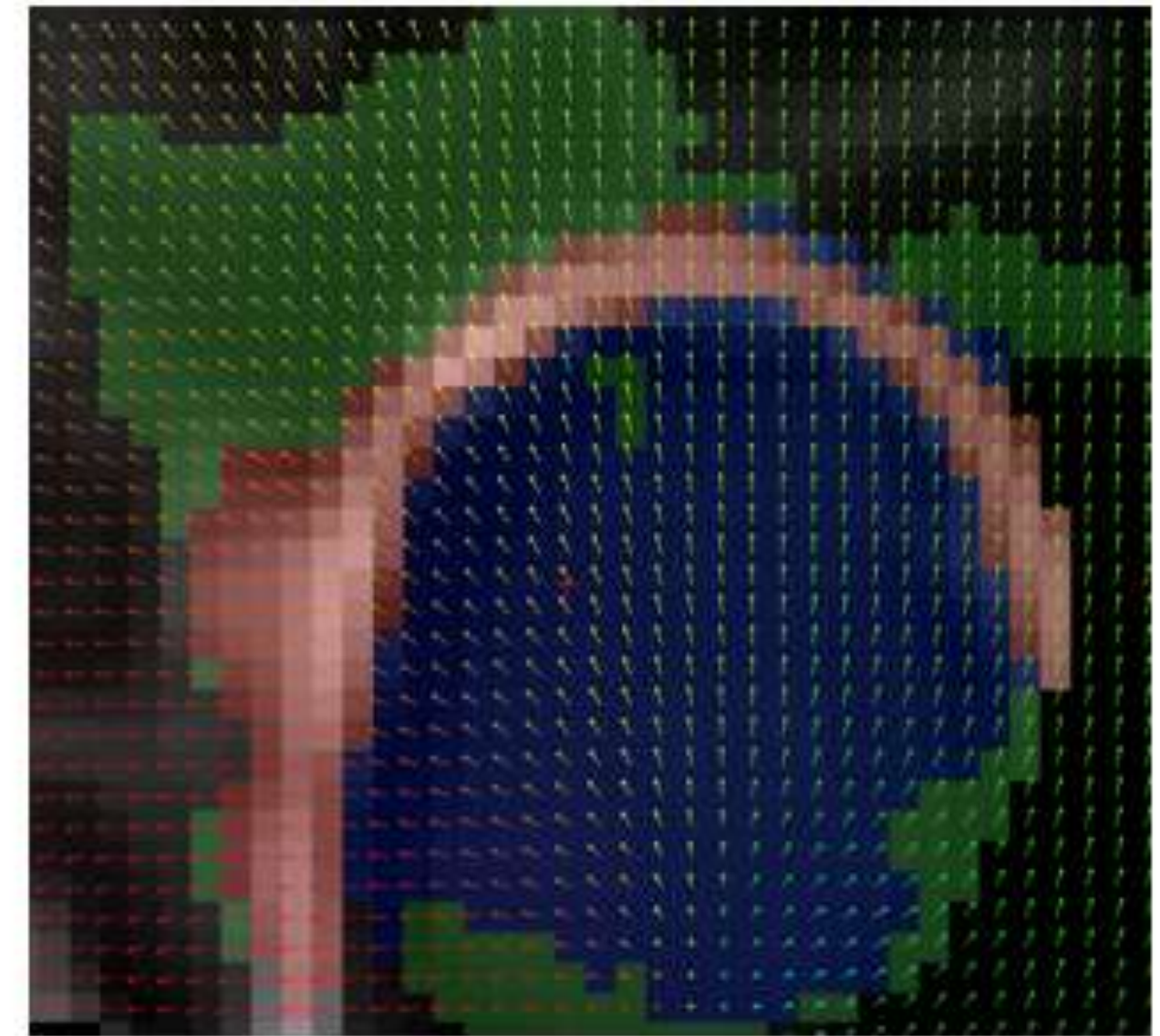
*Radial growth model*



*Synthetic  
deformation*



*Non-rigid registration*

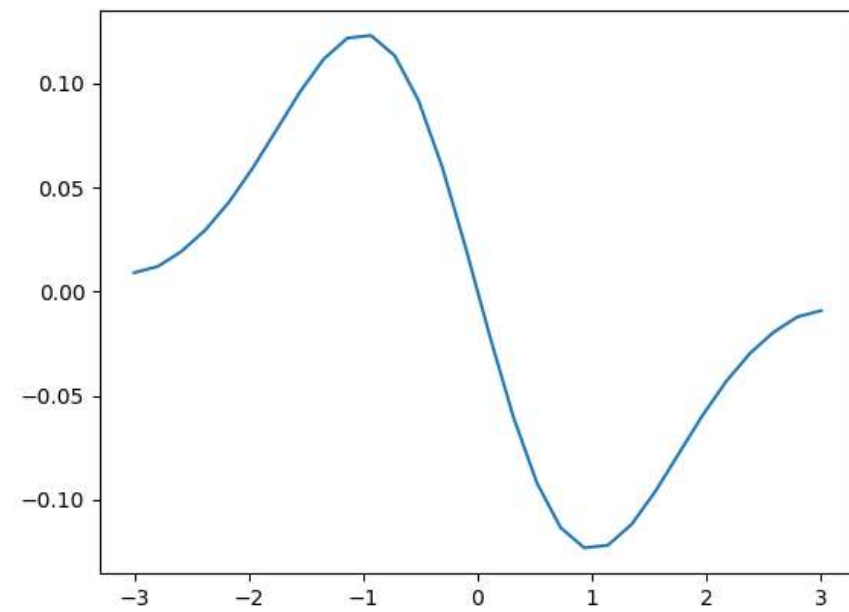




# Model of displacements from one examination to the next

1D

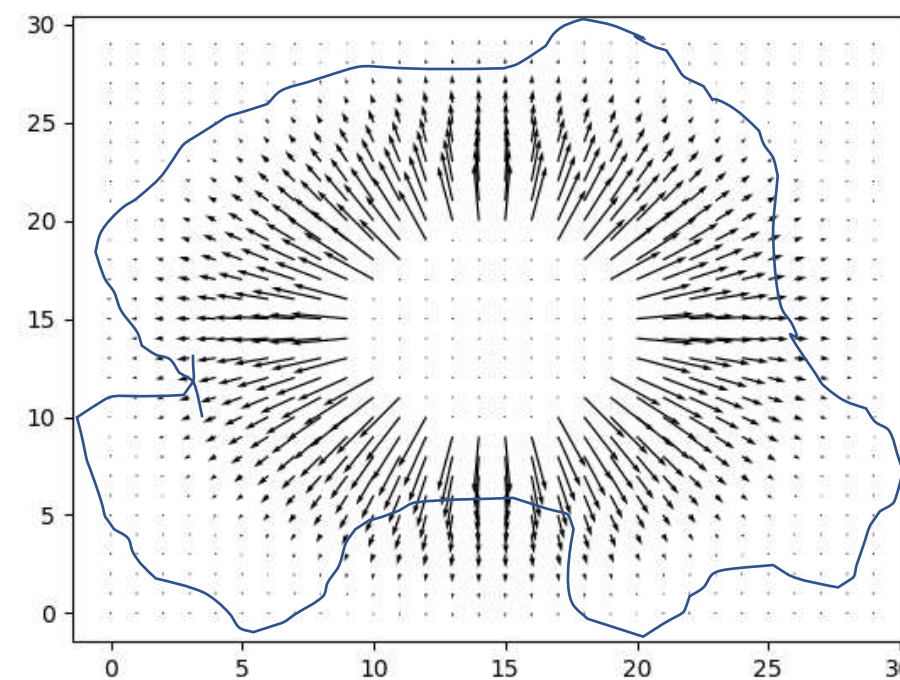
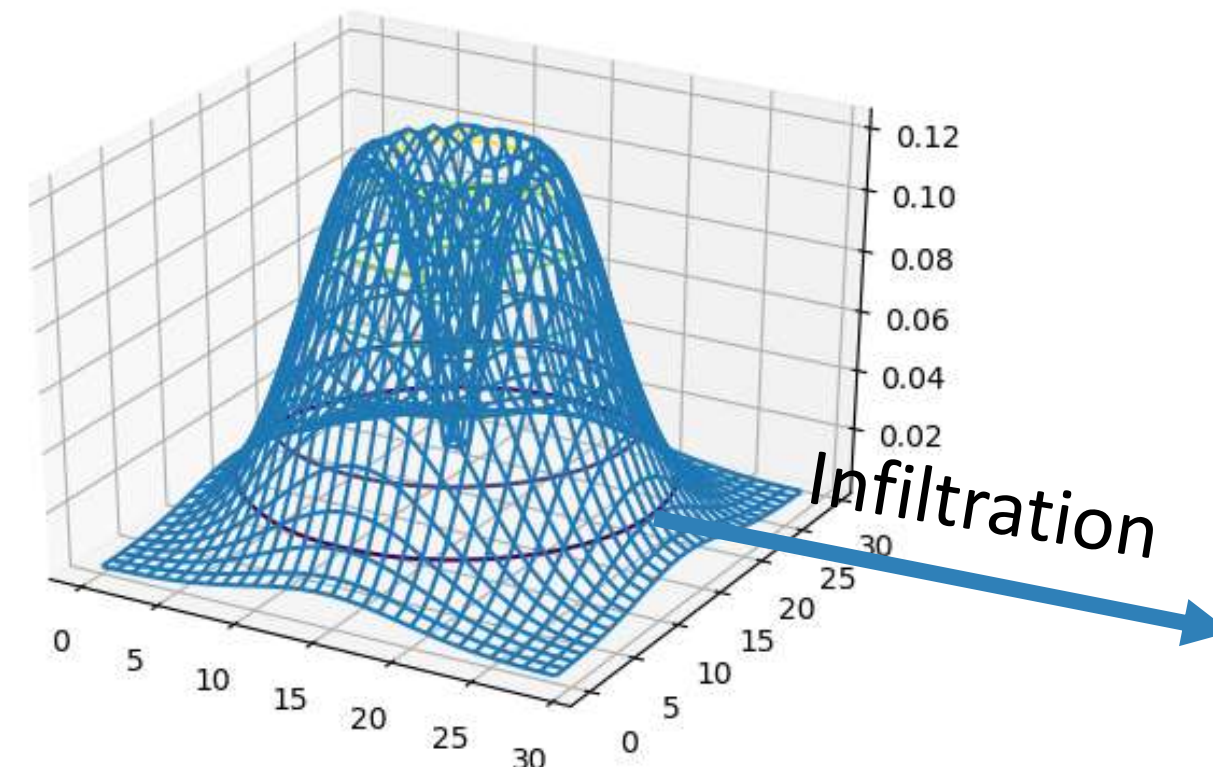
Displacement



Tumor cross section

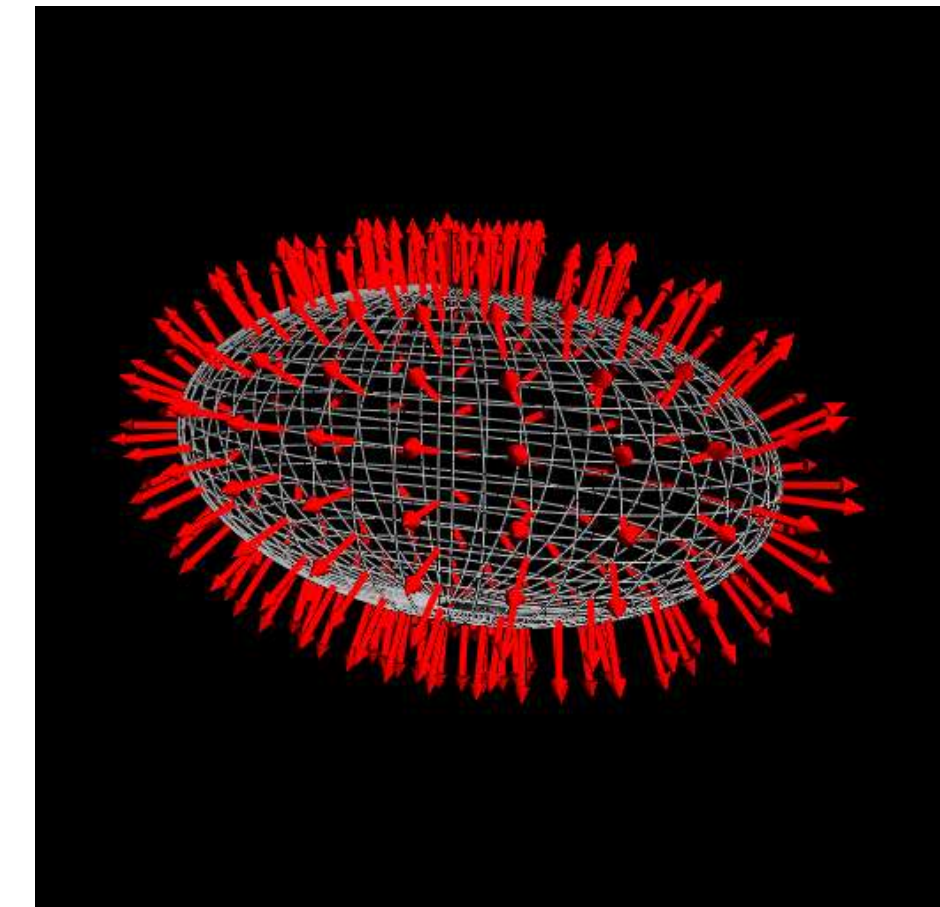
2D

Displacement



Tumor cross section

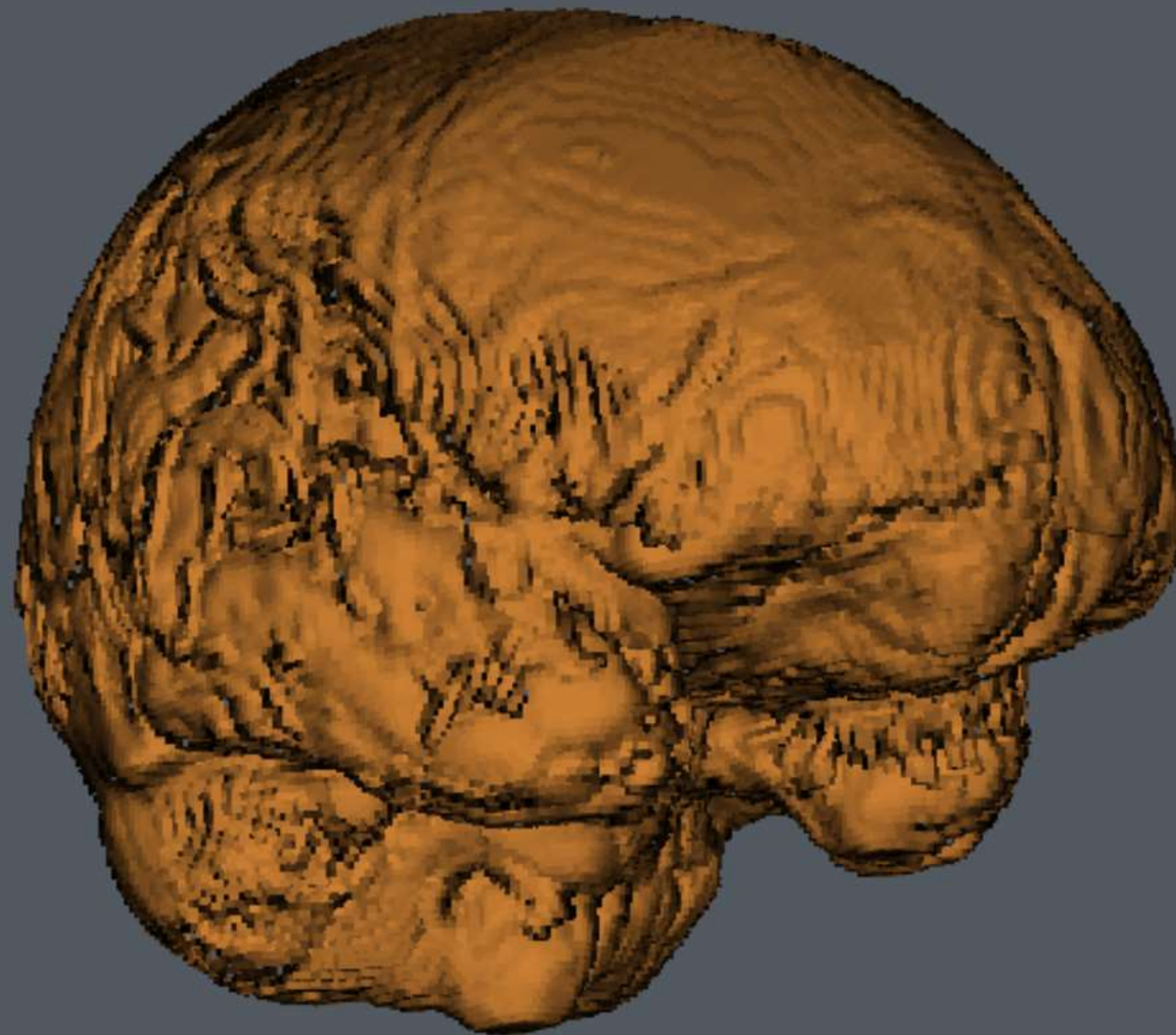
3D





Shaded surface, CPU

- DCM
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- 
- 2D
- 3D
- Q
- R
- vtk
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- ×



- 1. 2-T1c.nii.gz
- 2. warped.nii.gz
- 3. 3-T1c.nii.gz
- 4. directional-
- 5. neg-field-8.
- 6. interp-neg-1
- 7. 2-Tumorma:
- 8. gaussian.ni
- 10. 0;perlin-noi
- 11. 1;perlin-noi

Level 127,500000 Linear Window 255,000000



Shaded surface, CPU

- DCM
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- 2D
- 3D**
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- R
- vtk
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- 1. 2-T1c.nii.gz
- 2. warped.nii.gz
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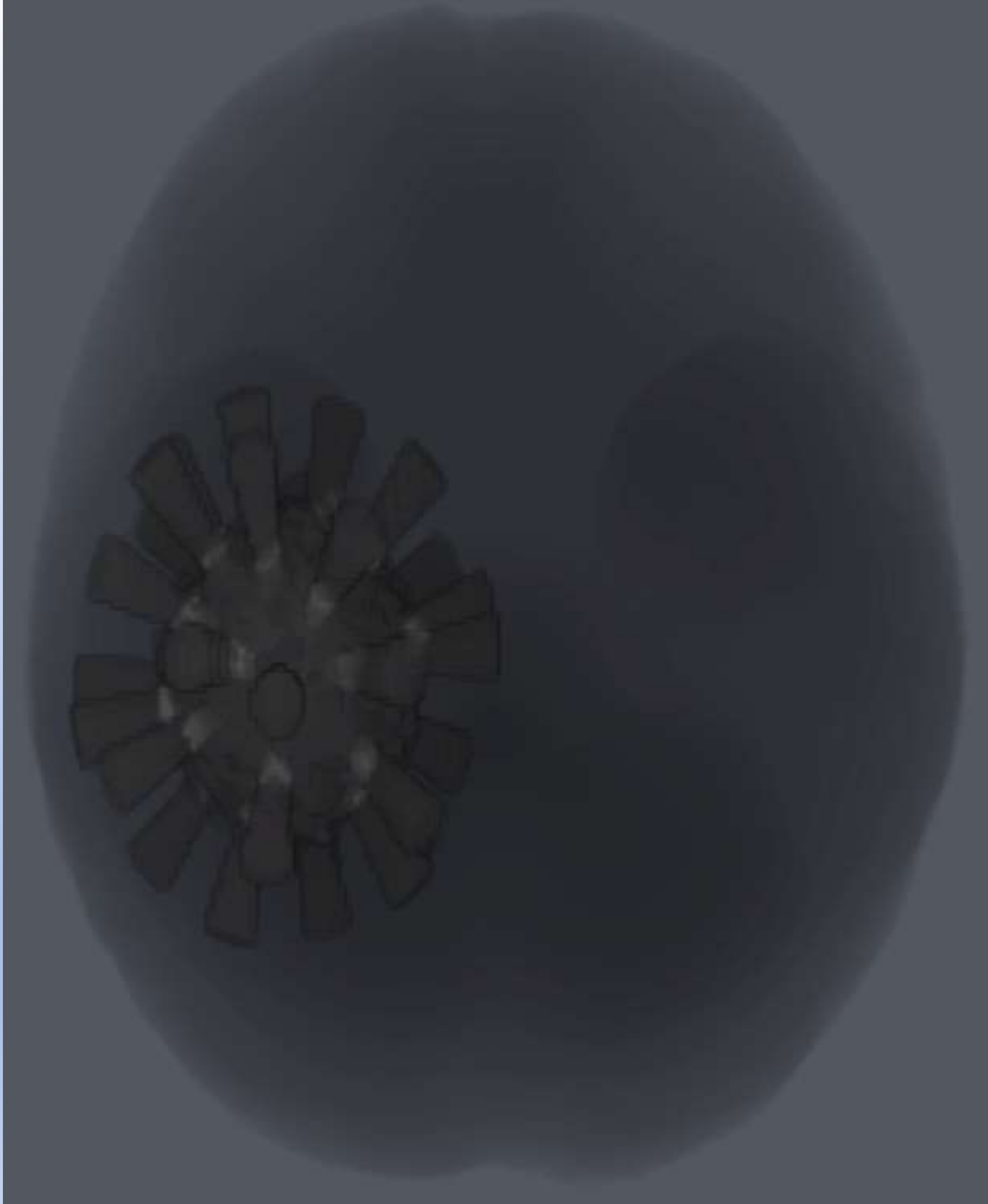
Shaded surface, CPU

- DCM
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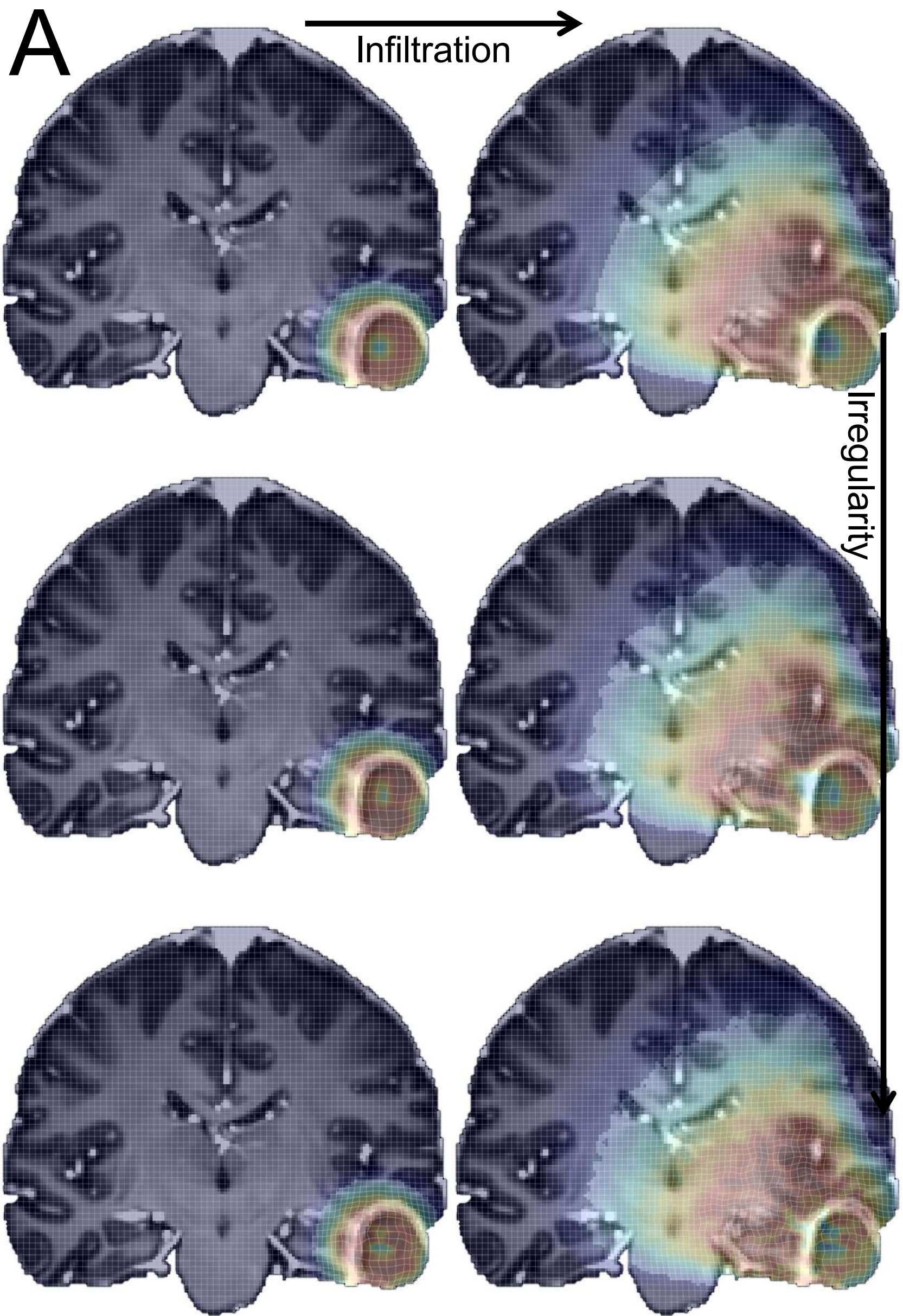
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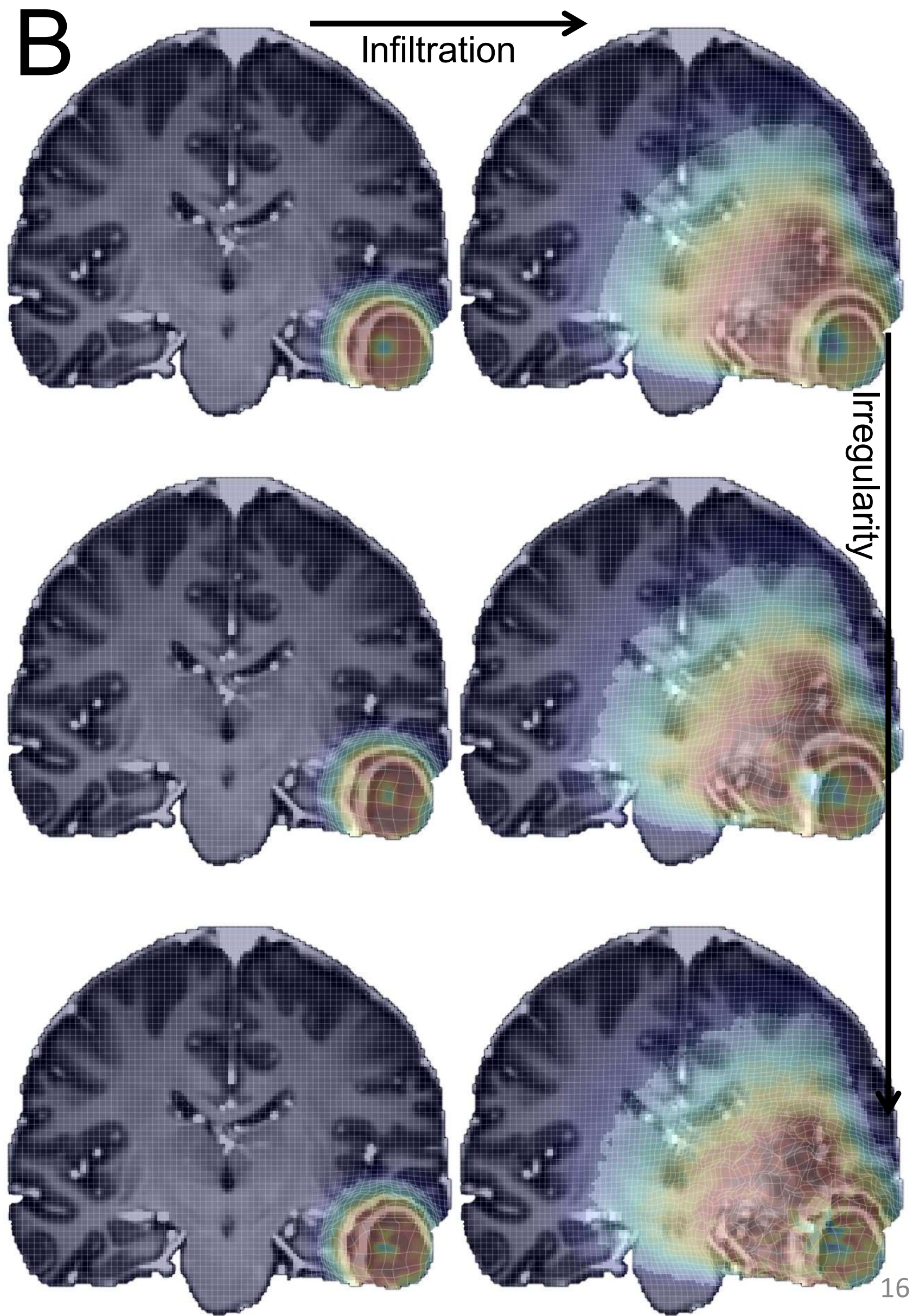




3 mm displacement



8 mm displacement

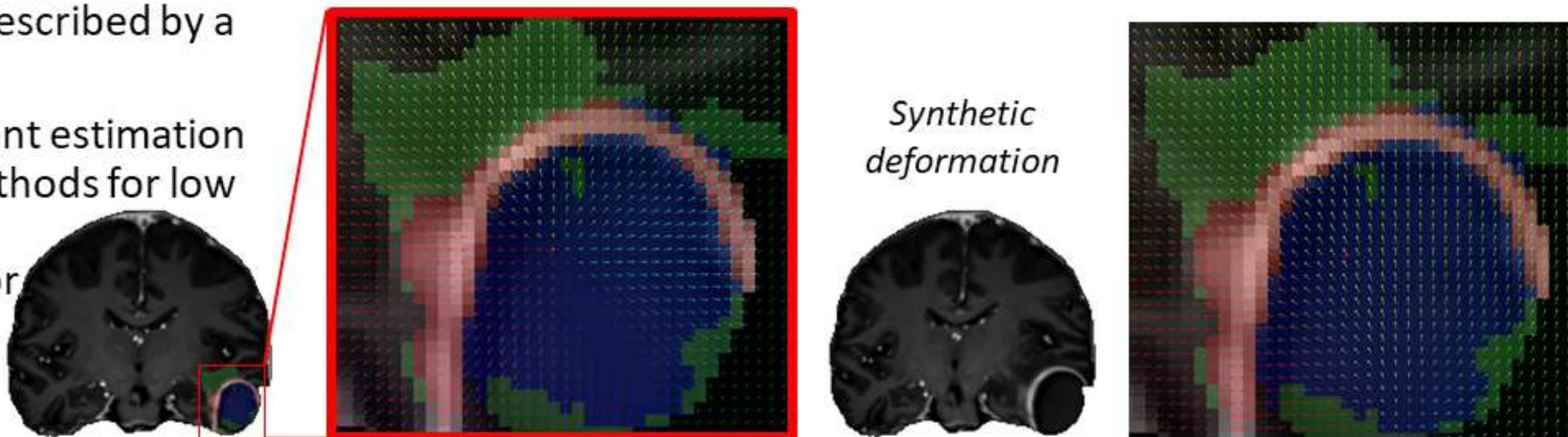




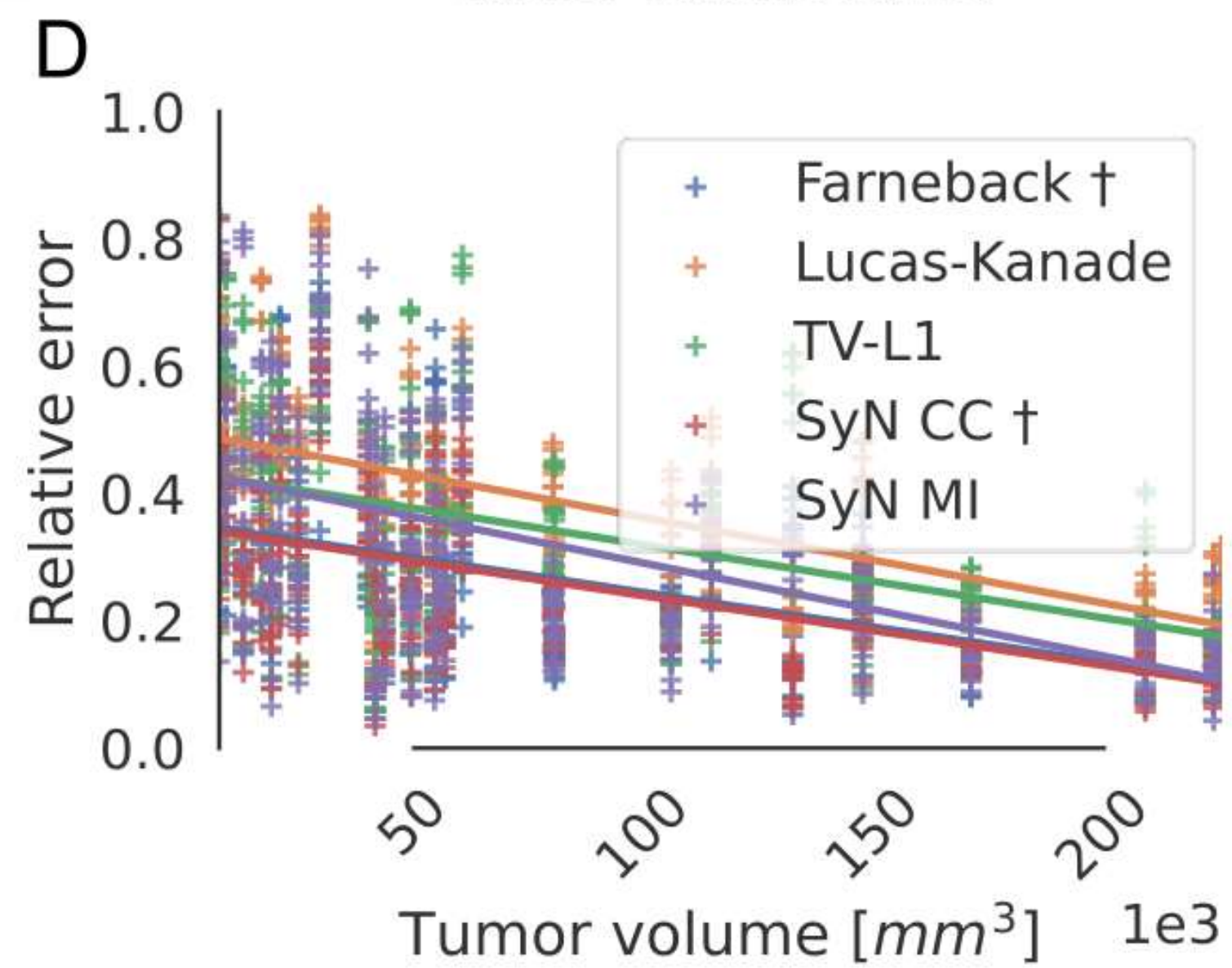
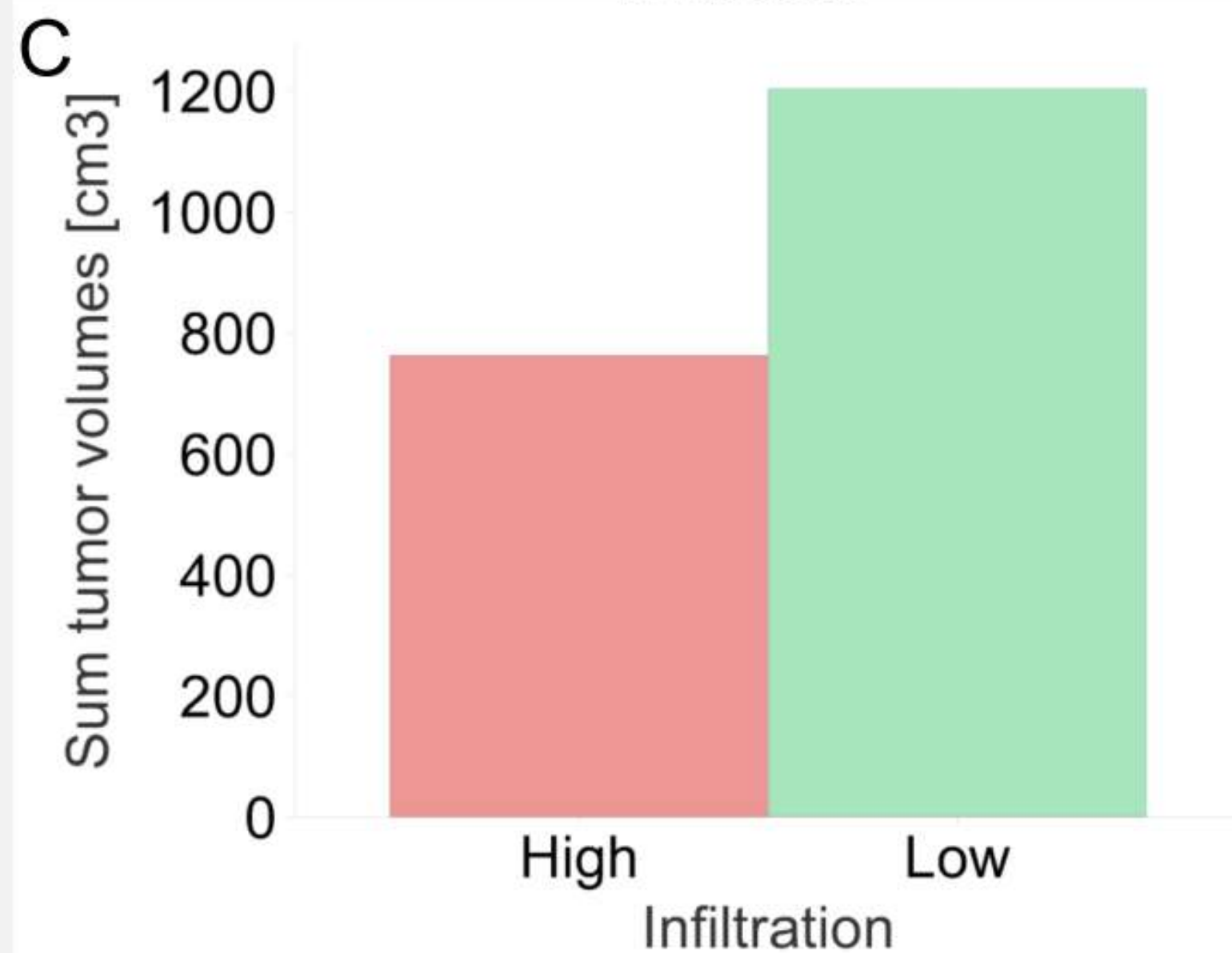
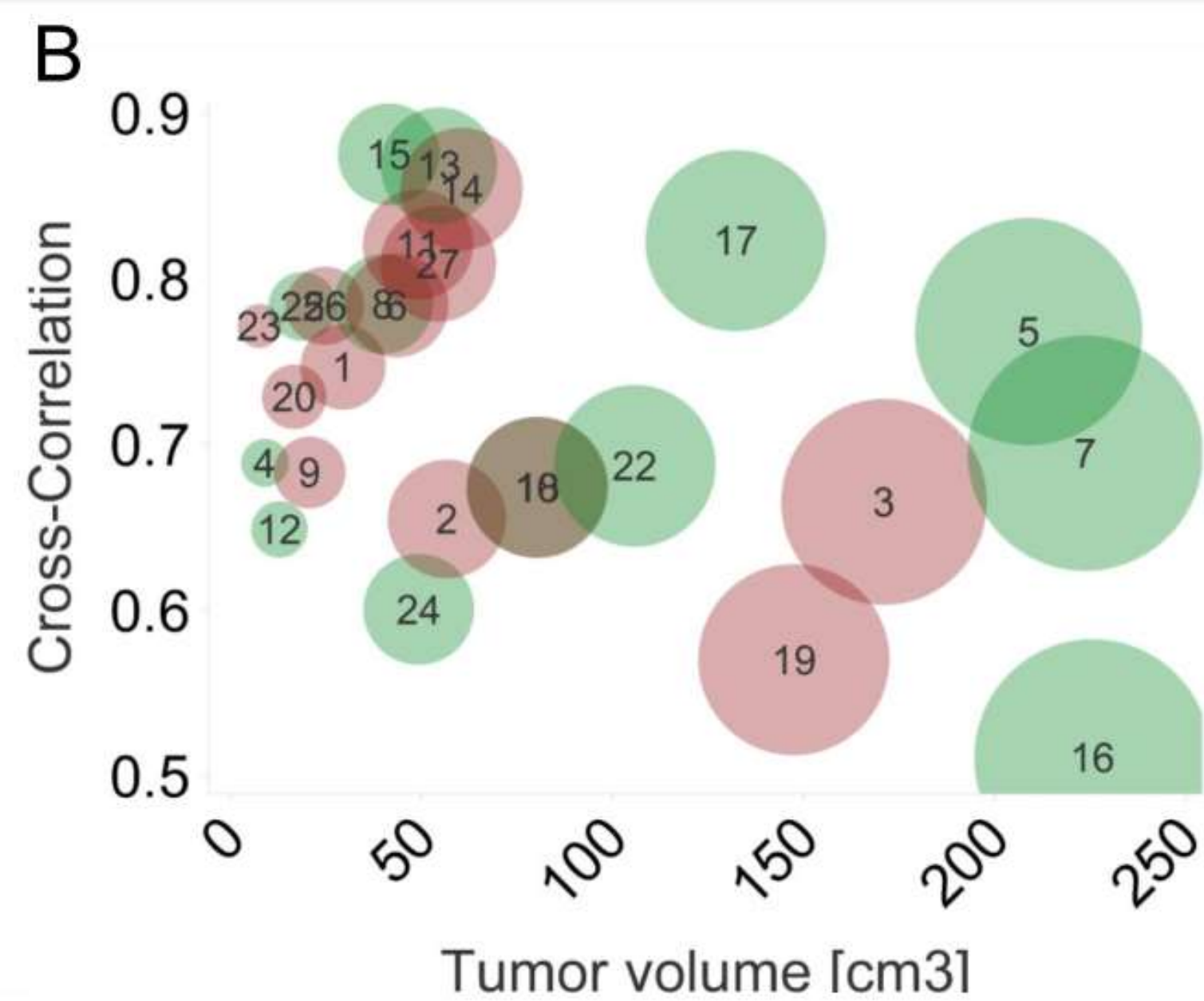
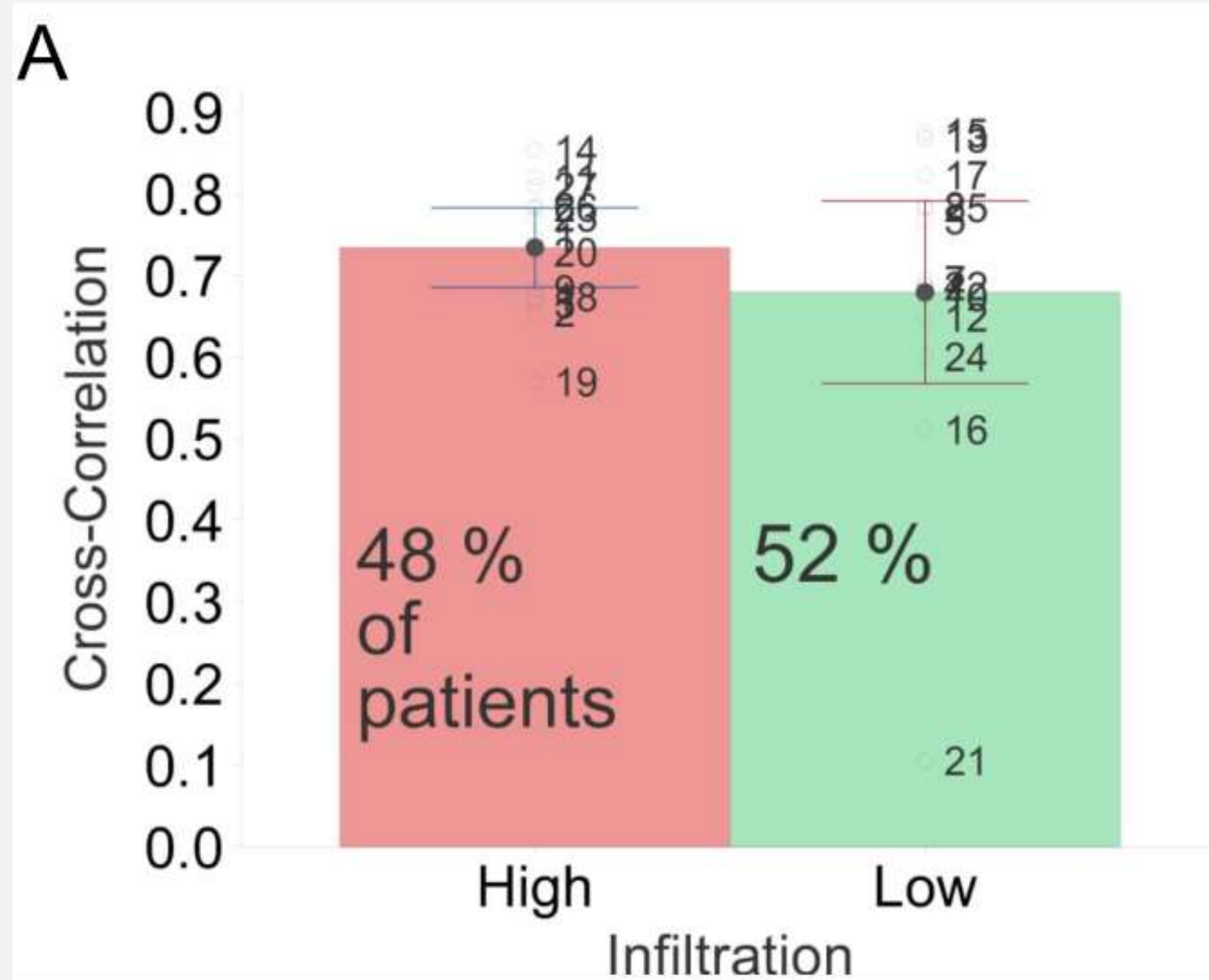
## A Parametric Evaluation of State-of-the-art Image Registration Methods for Assessing High-Grade Glioma Growth by Synthetic Modeling.

Ivar T. Hovden MS, Elies Fuster-Garcia PhD, Jingpeng Li MS, Atle Bjørnerud PhD, Christopher Larsson PhD, Siri F. Svensson MS and Kyrre E. Emblem PhD

- Tissue displacement from non-rigid registration of magnetic resonance images, may constitute as a valuable biomarker in characterizing cancer progression and detecting early tumor recurrence in high-grade Glioma.
- Voxel-wise accuracies of five state-of-the-art non-rigid registration methods were evaluated within necrotic (blue), contrast-enhanced (red) and edematous (green) lesions for 27 patients under different simulated conditions of maximum tissue displacement, tumor infiltration *Radial growth model* and growth irregularity, as described by a radial growth model.
- Significant lower displacement estimation errors for all registration methods for low (3 mm) maximum tissue displacement and high tumor infiltration, compared to the alternatives 8 mm and low tumor infiltration.







# Feedback from JMRI -

- R1: Lack of novelty and significant limitations (...)
- R2: «The authors evaluate the performance of registration methods to synthesize predicted displacements of brain in n=27 patients with high grade glioma. Results generated using data at one time-point are compared with images generated two weeks later. The authors use various parameters in the prediction and evaluate results using five methods. Two of the five show superior results.»

1. Many of the methods are ad hoc, not justified, and seem to have negligible physical or biological basis. For example, why the seemingly arbitrary selection of 3mm and 8mm radial tissue displacement?
2. The overall significance of the work seems questionable. If one wishes to determine the possible growth of a glioma after a time of no treatment or the possible reduction in mass after treatment, then one can simply perform a followup MRI exam
3. There is no testable hypothesis presented. Presumably the authors wish to compare their synthetic prediction with ground truth as represented in the scans performed two weeks later. However, there is no clear description of such a comparison, and there is no clear presentation in the Results showing such a comparison.
4. As presented, the information in the figures has negligible value. There are no figure legends. There is no clear comparison of synthetic vs. actual images.
5. Although the authors state that two methods (Syn ANTS with cross correlation and Farneback optical flow) had better performance than the other three, it is not clear if the performance of these two methods is adequate for some possible imaging task.



# 3rd publication

Distinguishing between «good» and «bad» treatment response by quantifying overall shrinkage or growth

Days, interval

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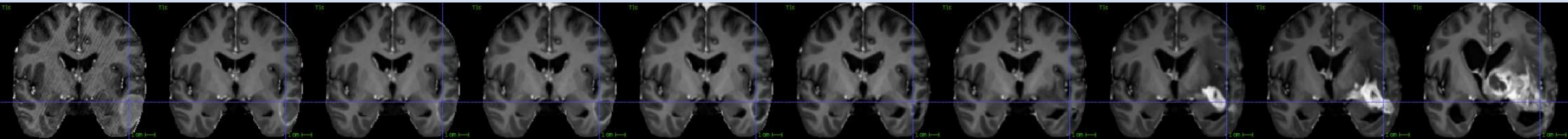
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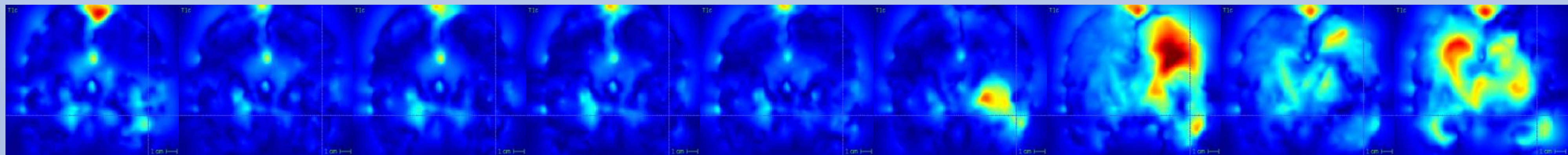
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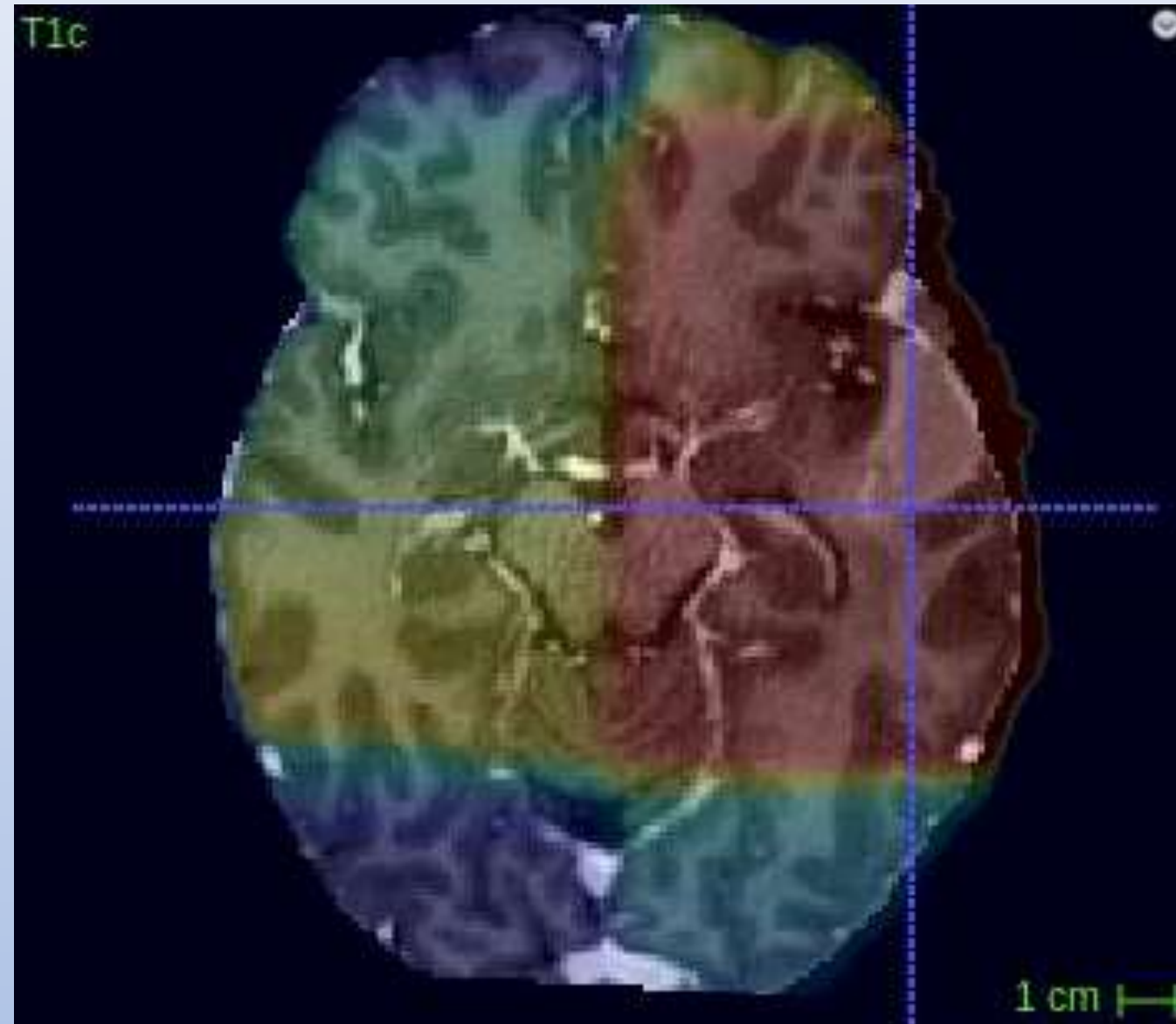
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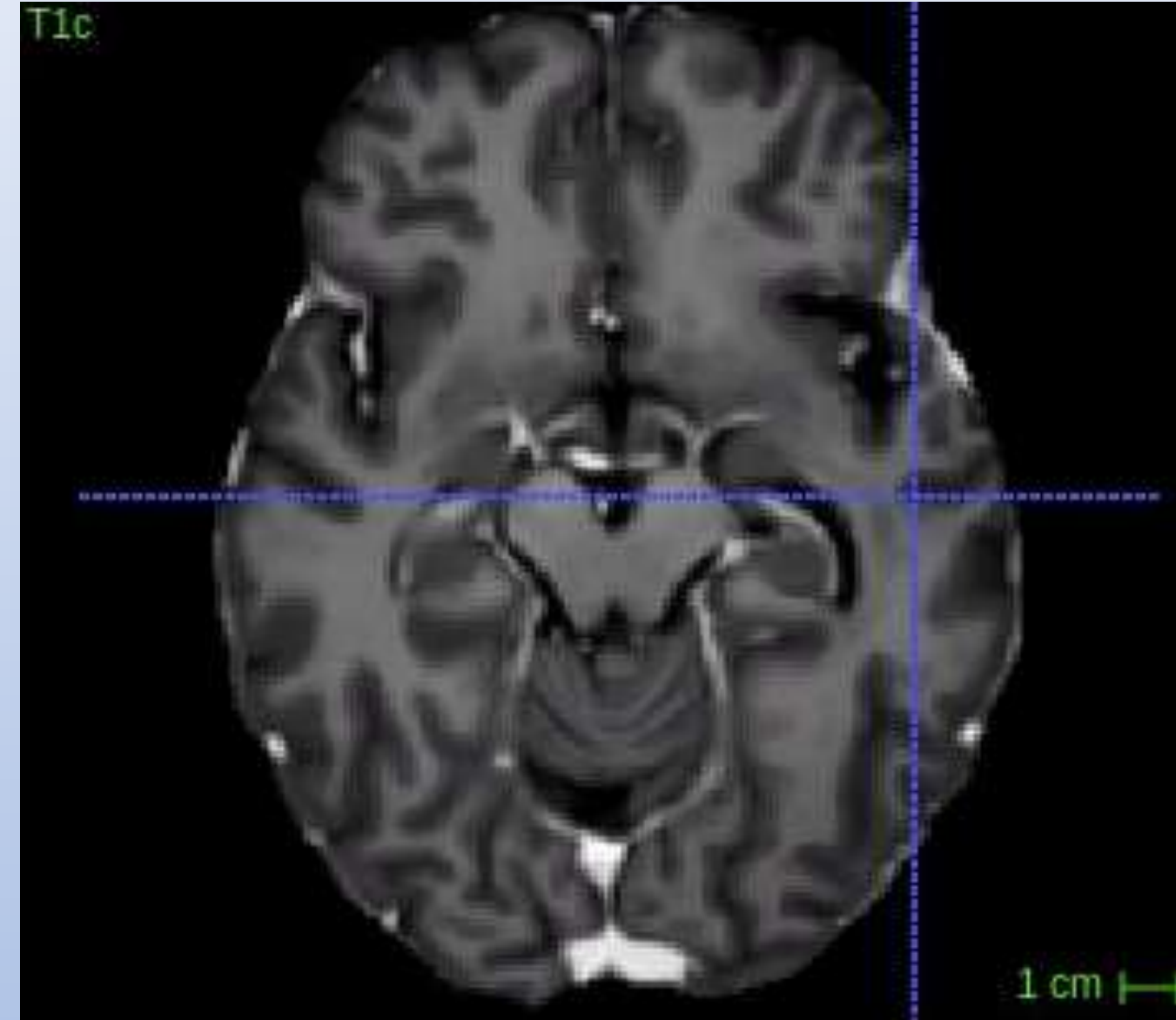


# Radiation dose distribution

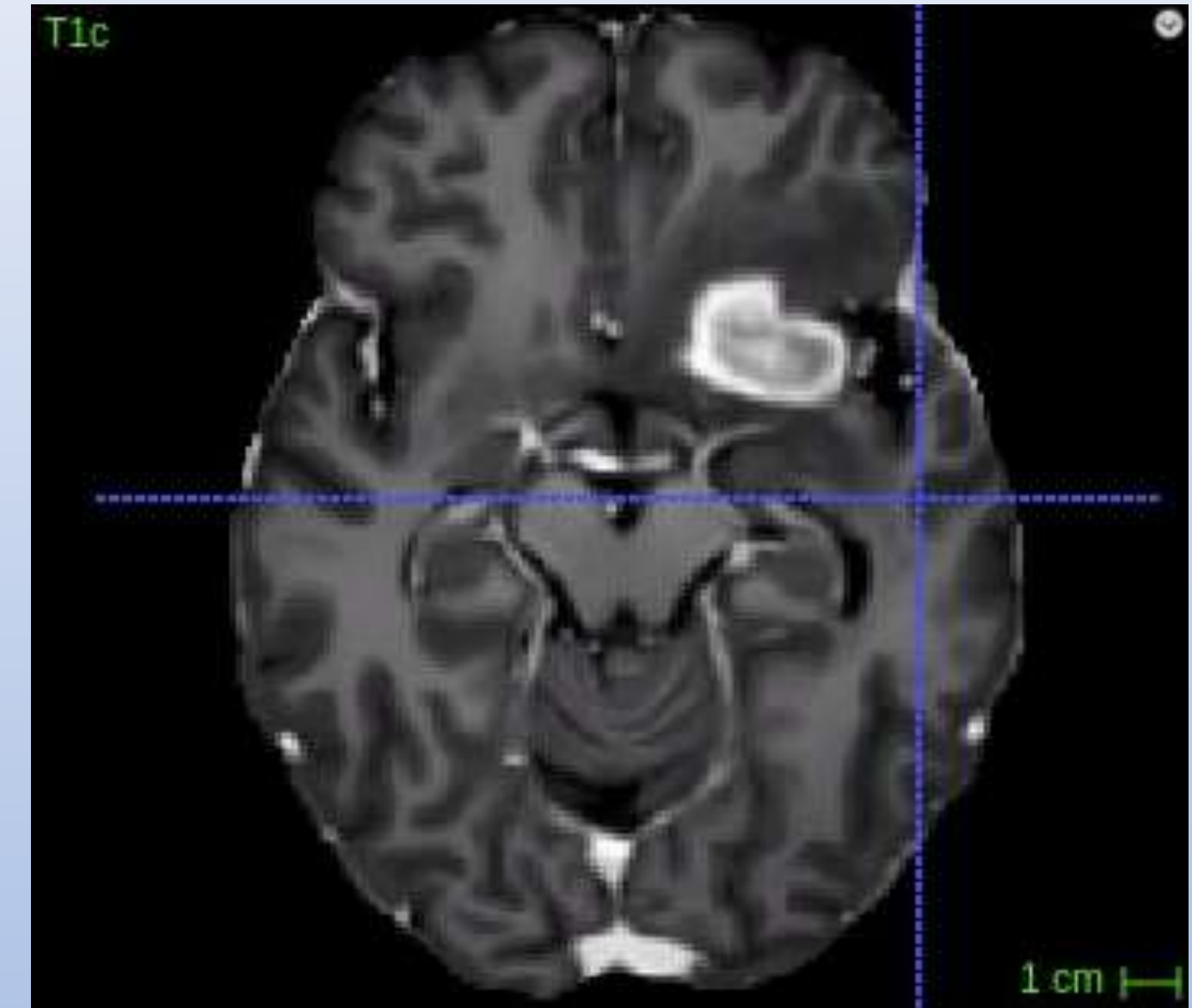
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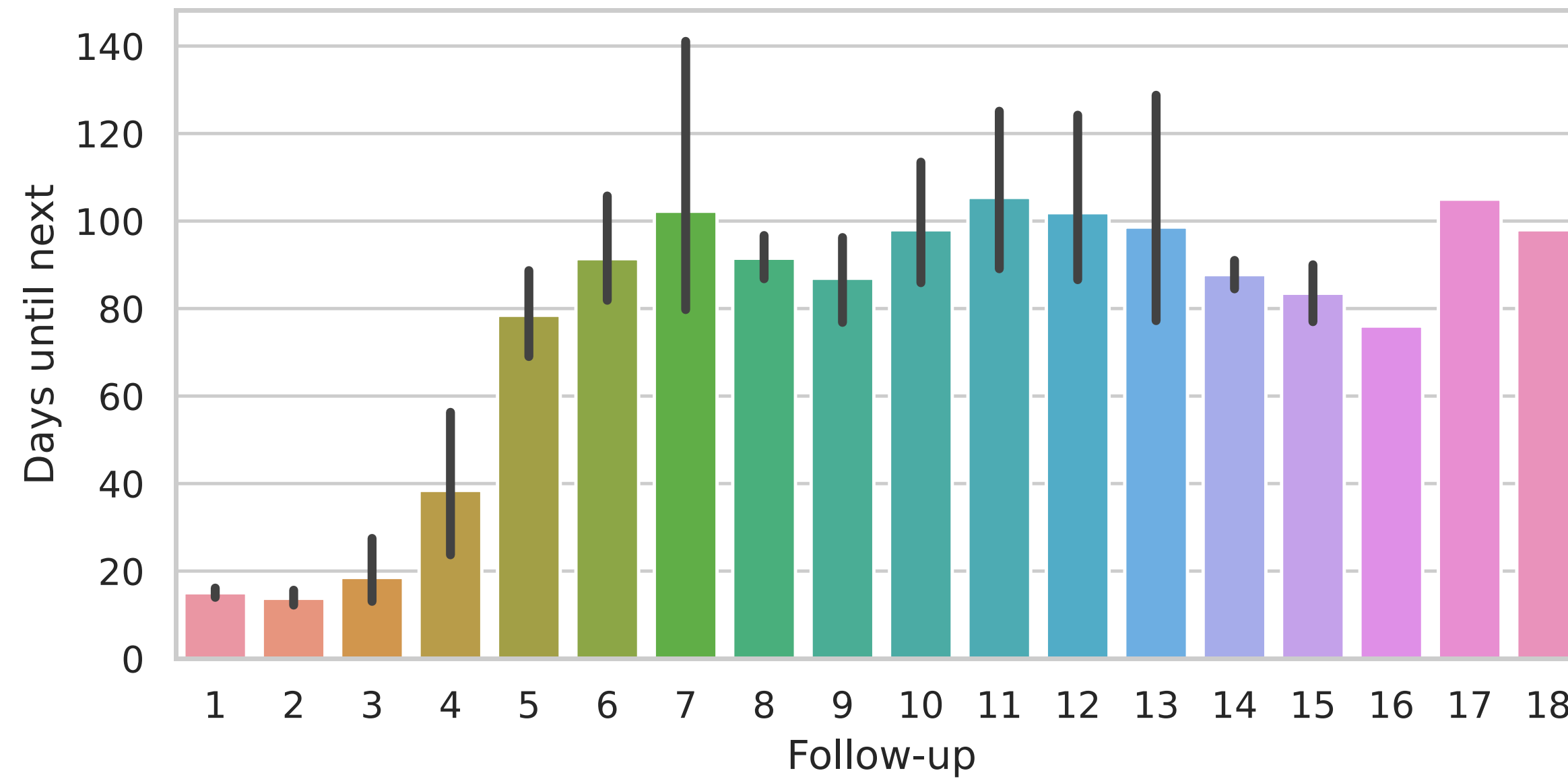
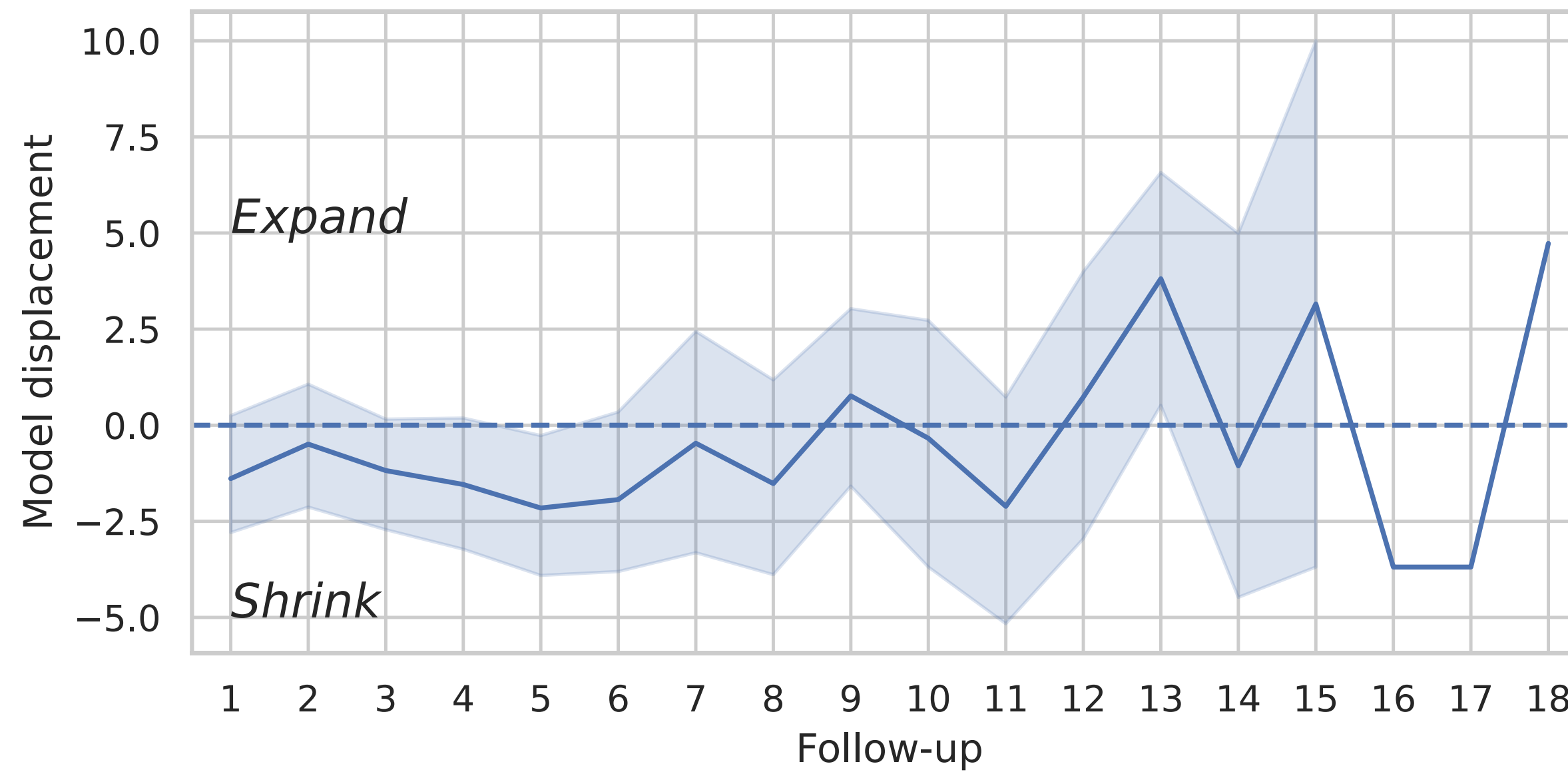


123 days

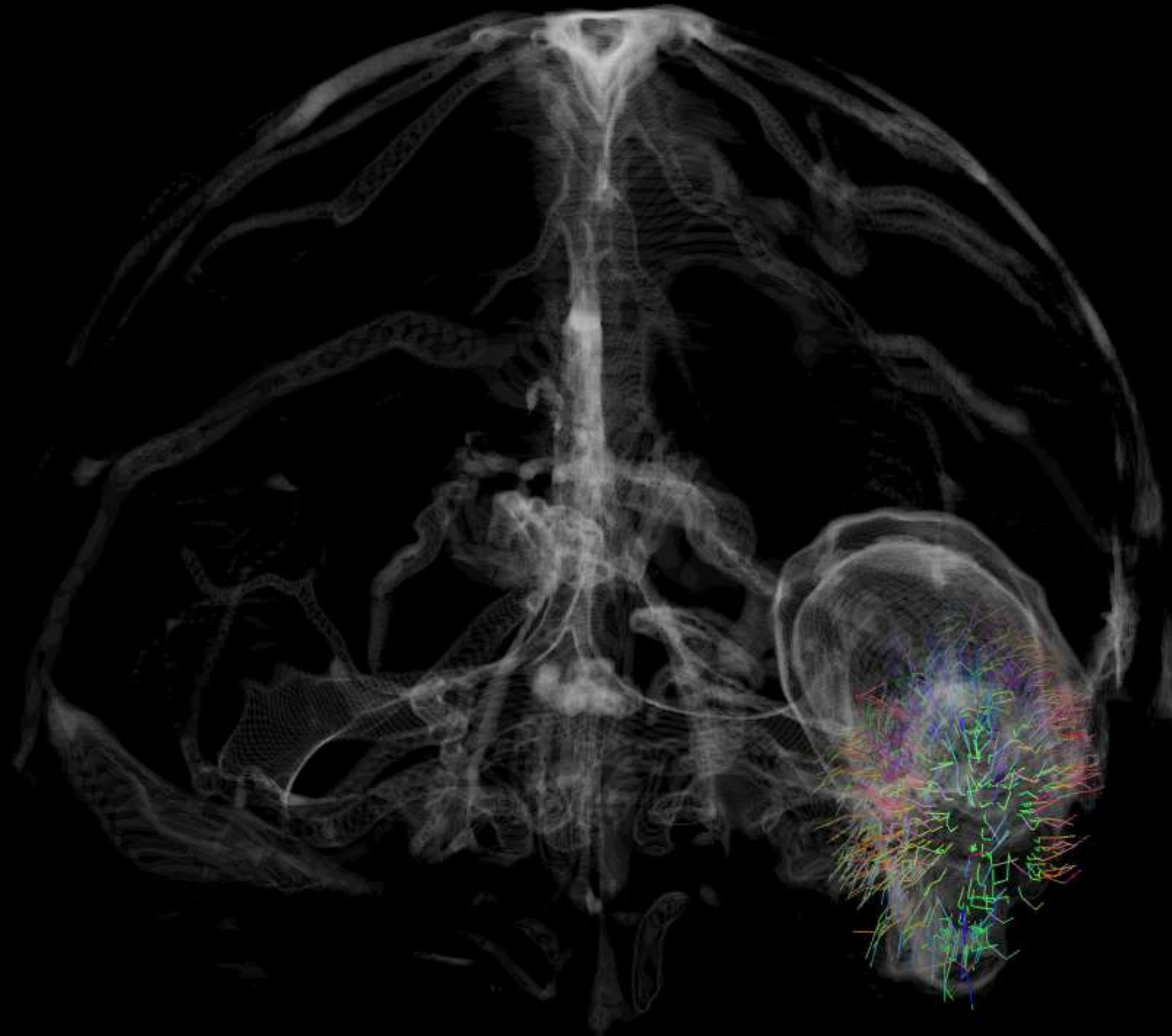
Shrinkage

85 days

Recurrence







growth pathlines from  
contrast-enhanced lesion according  
to best fit radial deformation model.  
Compare with true MRI.

resetCamera		
animated		
Model displacement		
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lowerThreshold	<input type="range" value="1.9"/>	1.9
upperThreshold	<input type="range" value="19"/>	19
swipingThreshold	<input type="range" value="3"/>	3
reset		
Max of longitudinal MRI		
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volumeRendering	<input checked="" type="checkbox"/>	
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lowerThreshold	<input type="range" value="129"/>	129
upperThreshold	<input type="range" value="179"/>	179
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indexY	<input type="range" value="121"/>	121
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Close Controls

- (Treatment related) aspects that can be interesting to relate to shrink and growth patterns?