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Tumor growth model applied for meningiomas : first clinical validation

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informatics mathematics Inria

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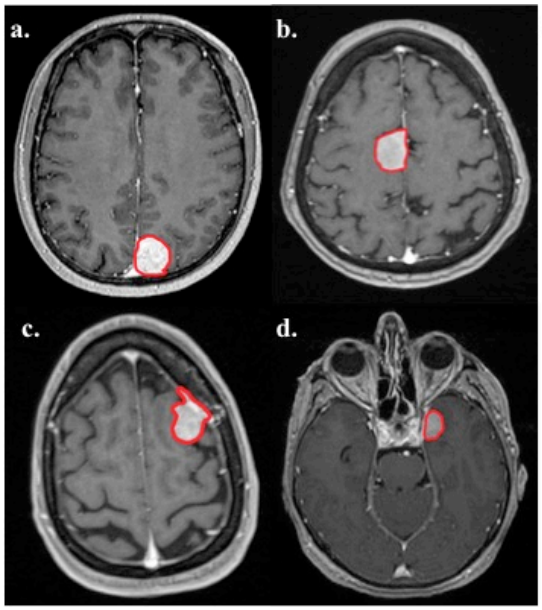
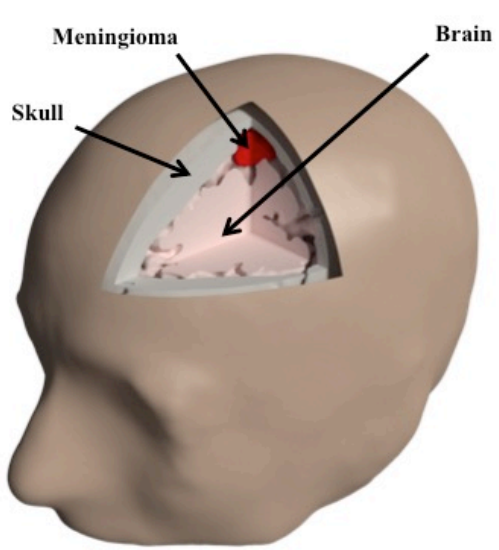
Meningiomas

- Intracranial tumor arising from uncontrolled mitosis of arachnoidal cells
- Meningiomas represents 30% of primary brain tumors
- Non malignant tumor with a slow growth rate

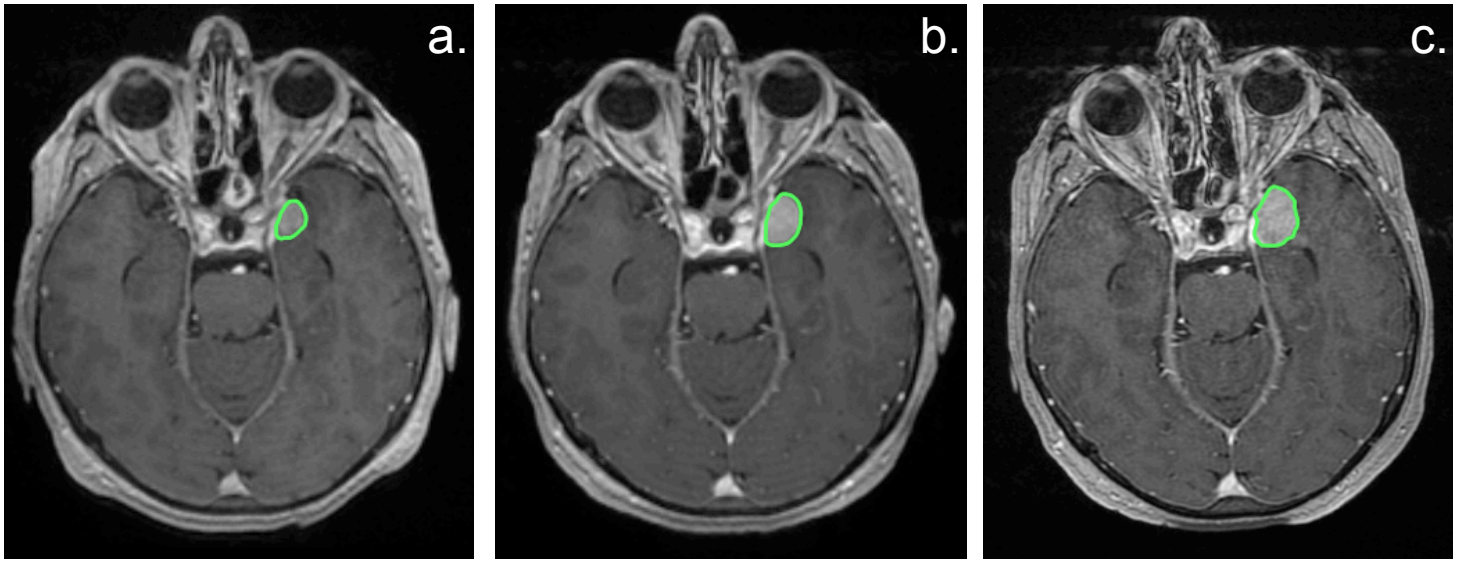




- **Tumor expansion may compress and permanently damages neighboring healthy tissues.**

Objectives

CHU Bordeaux (MRI T1 sequence, contrast agent: Gadolinium)

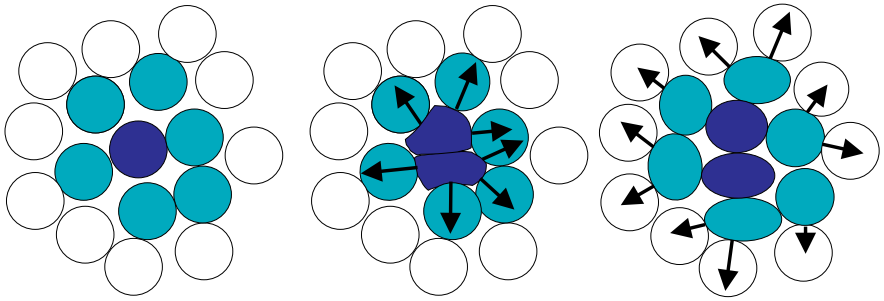


$\mathbf{t_0}$ = 0 day $\mathbf{t_1}$ = 169 days $\mathbf{t_2}$ = 330 days

- Can we **model** the meningioma growth?
- Can we **predict** (or at least estimate) the growth?

Clinical goal : can we predict the tumor volume and shape at time t_2 from the imaging data at t_1 and t_0?

How to model the meningioma growth ?



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- We consider one population of tumoral cells and the surrounding medium.
- The mitosis occurs homogenously in the tumour.
- The surrounding medium is simply pushed away by the tumoral cells with a speed that is directly linked to the mitosis capacity.
- The growth starts from the arachnoid towards the brain.

Prediction and simulation method

Spatial Model (3D)

2 parameters :

M : growth capacity

α : decreasing rate of M

Integration over space

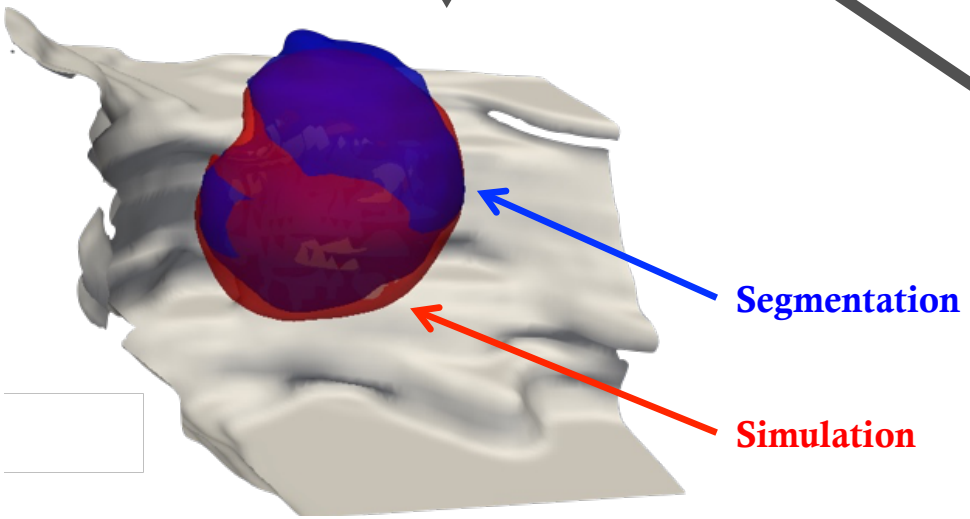
Tumoral Volume Equation over time (0D)

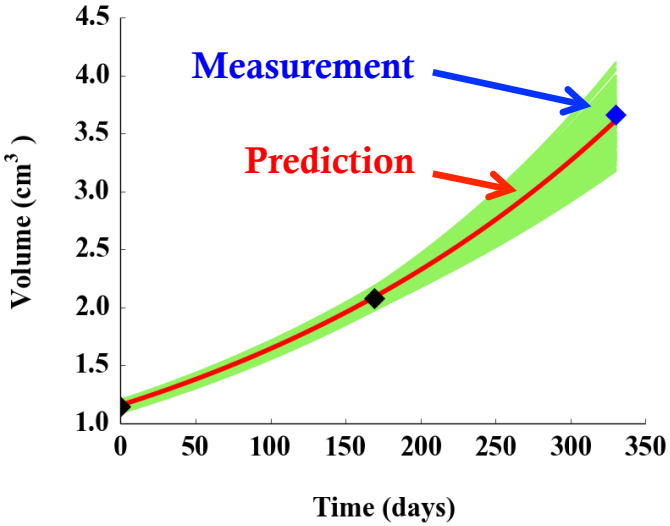
parameters : V_0, M_0, α

Personalization of the model with **3D** segmentations of the tumor

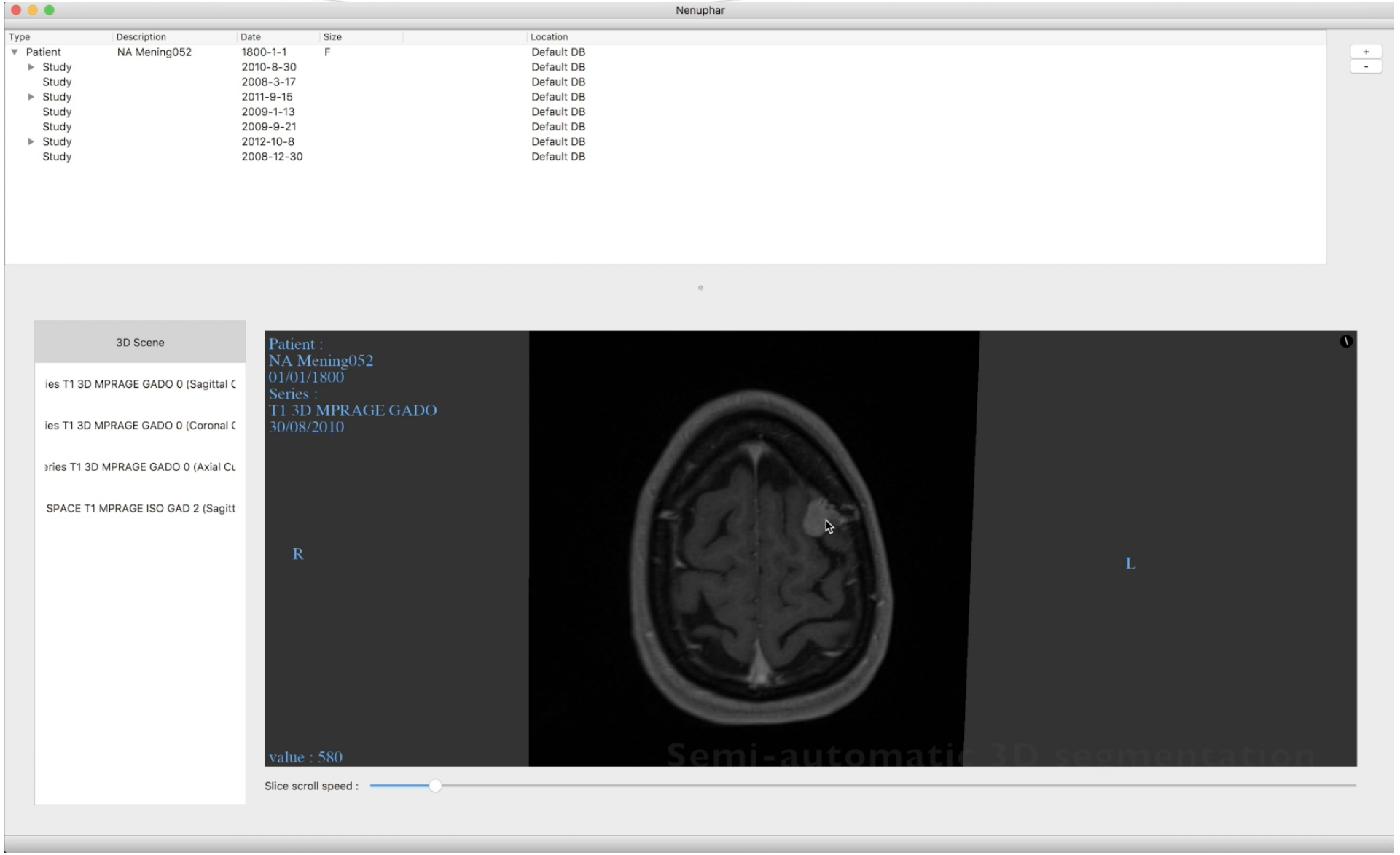
Personalized parameters M_0, α

3D Simulation of the meningioma growth

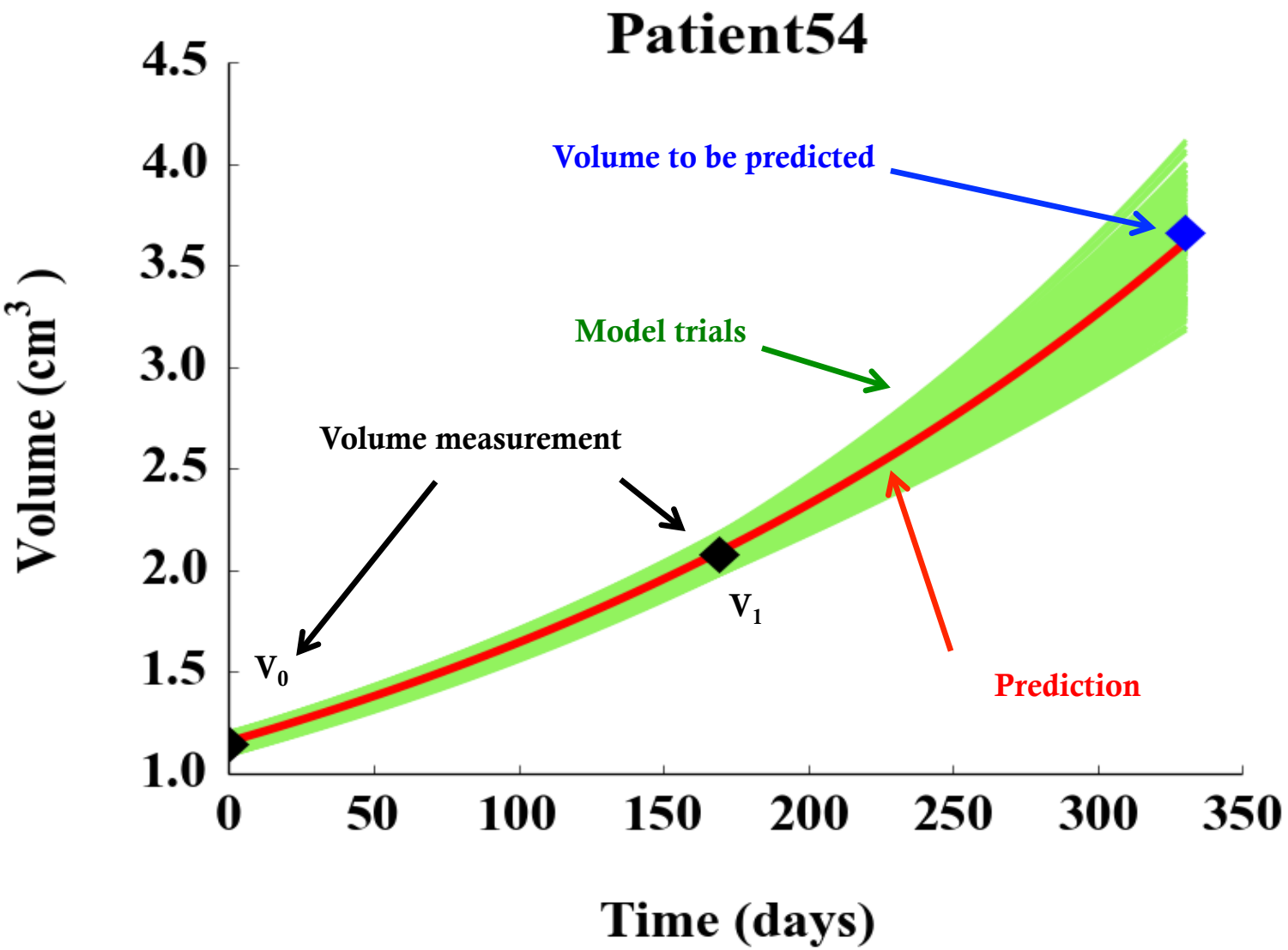




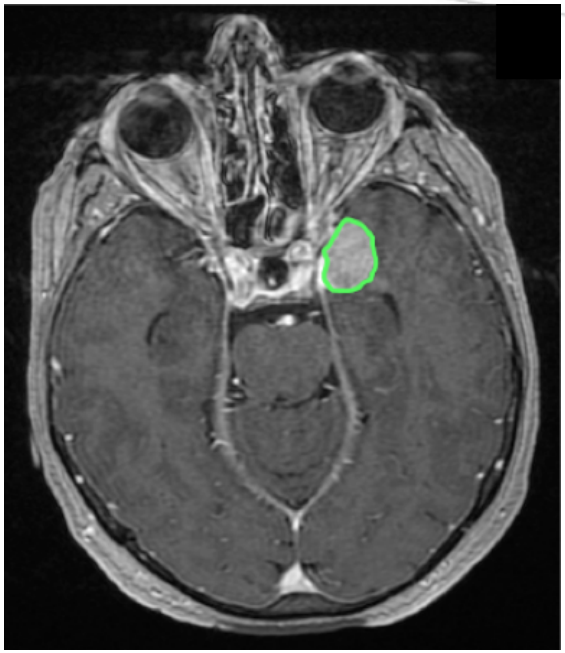
Semi-automatic 3D segmentation tool



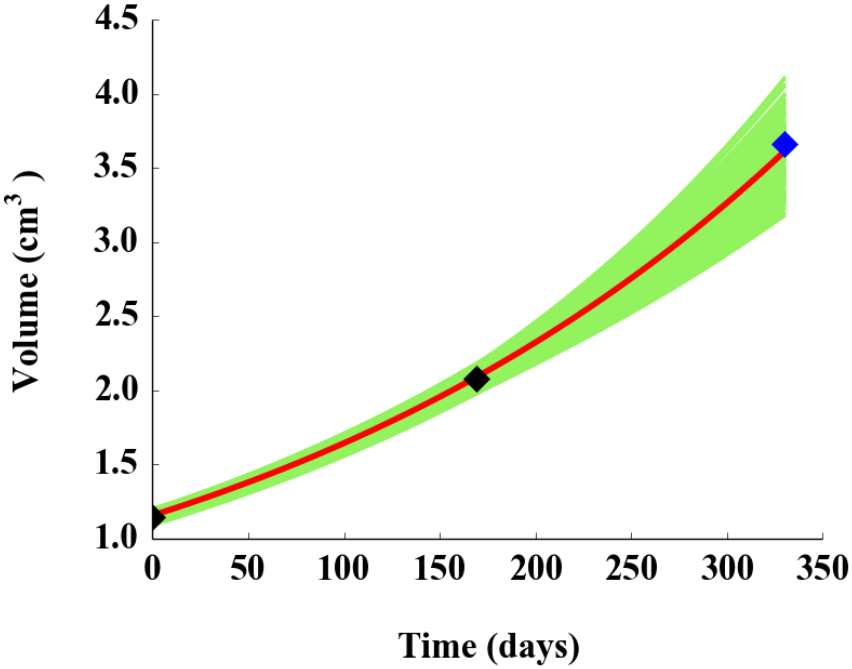
Model personalization

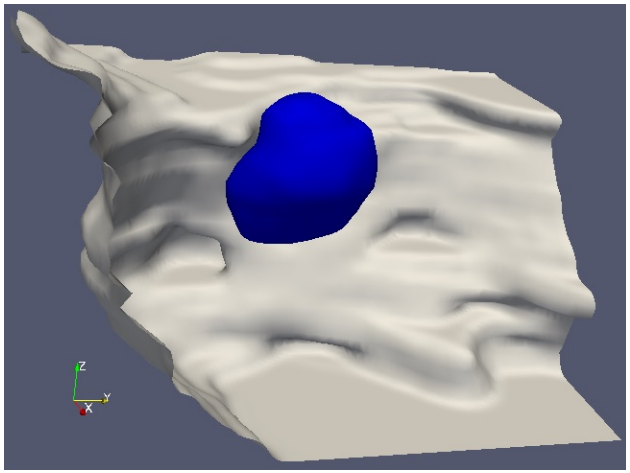


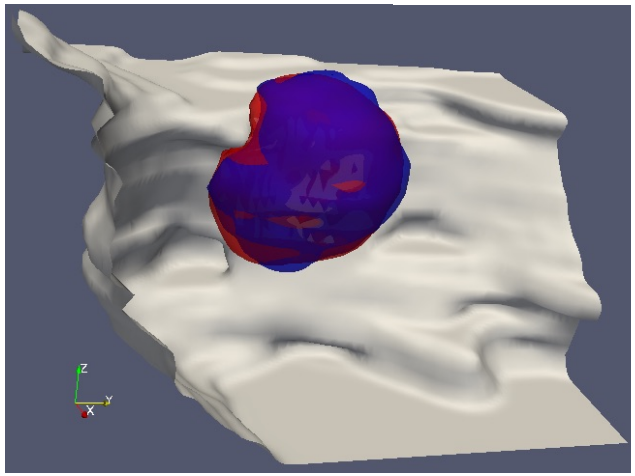
Example

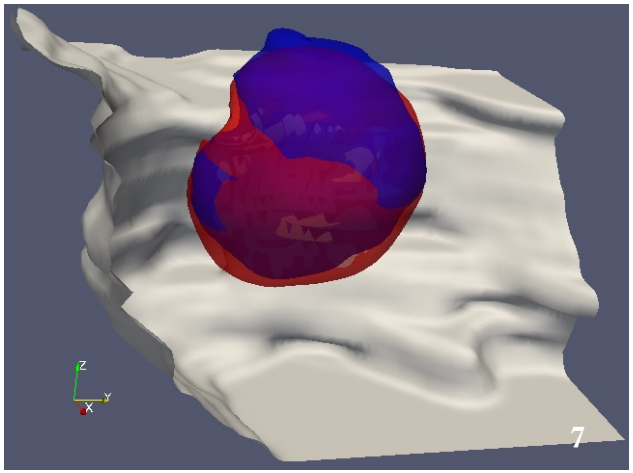


Case #54

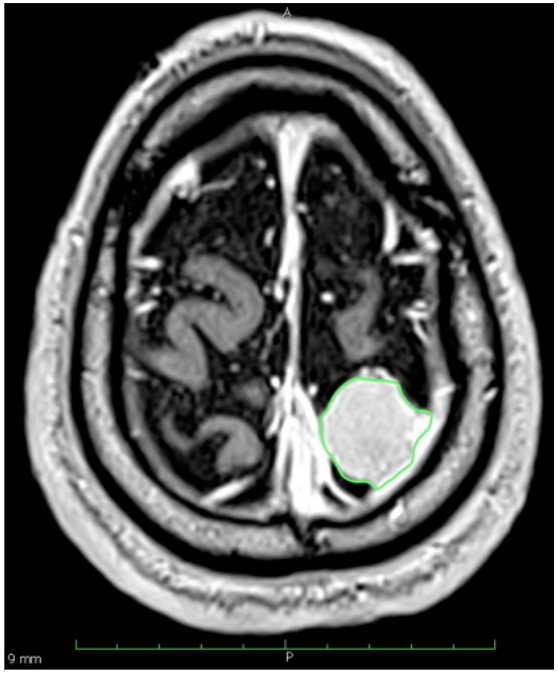




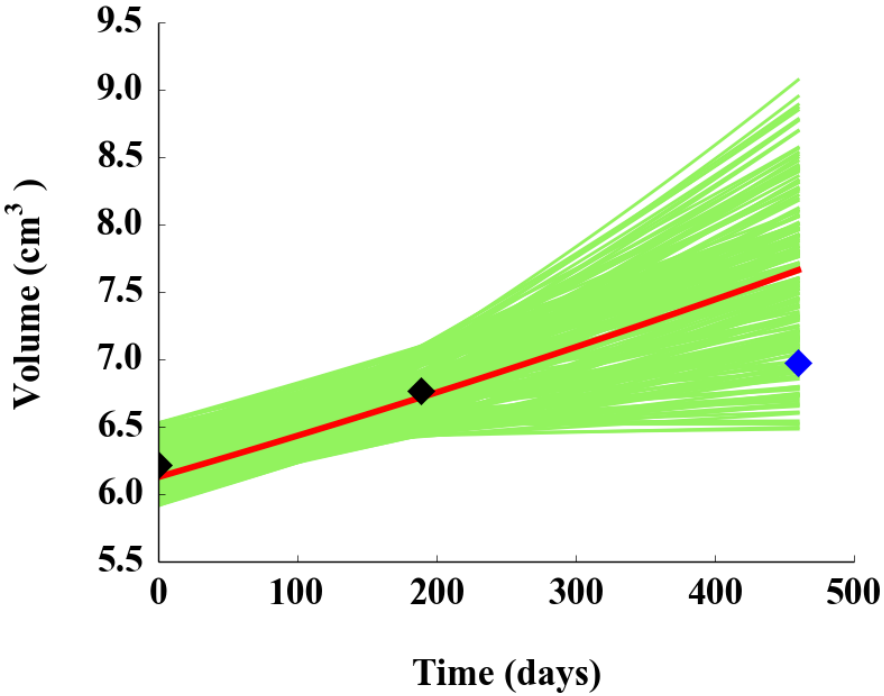


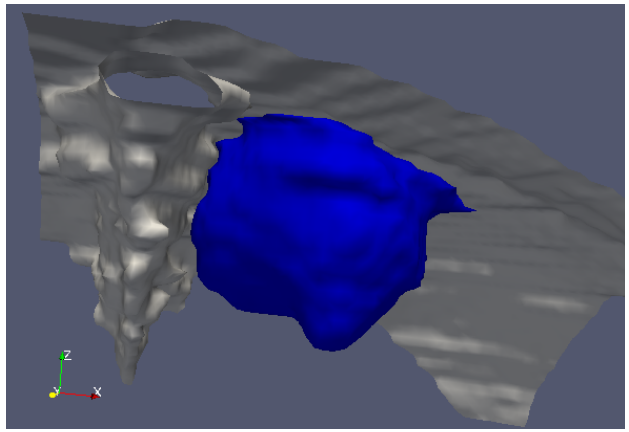


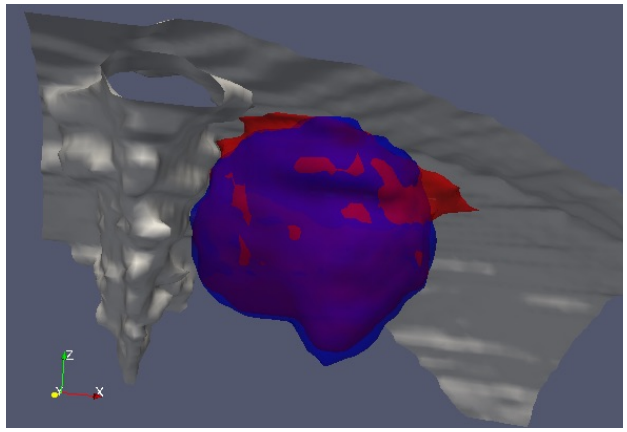
Example

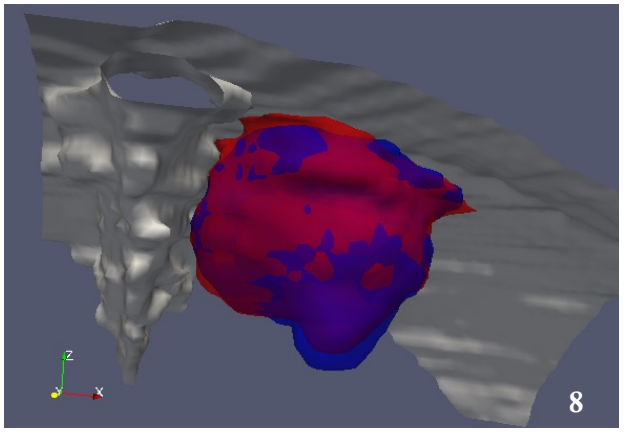


Case #6



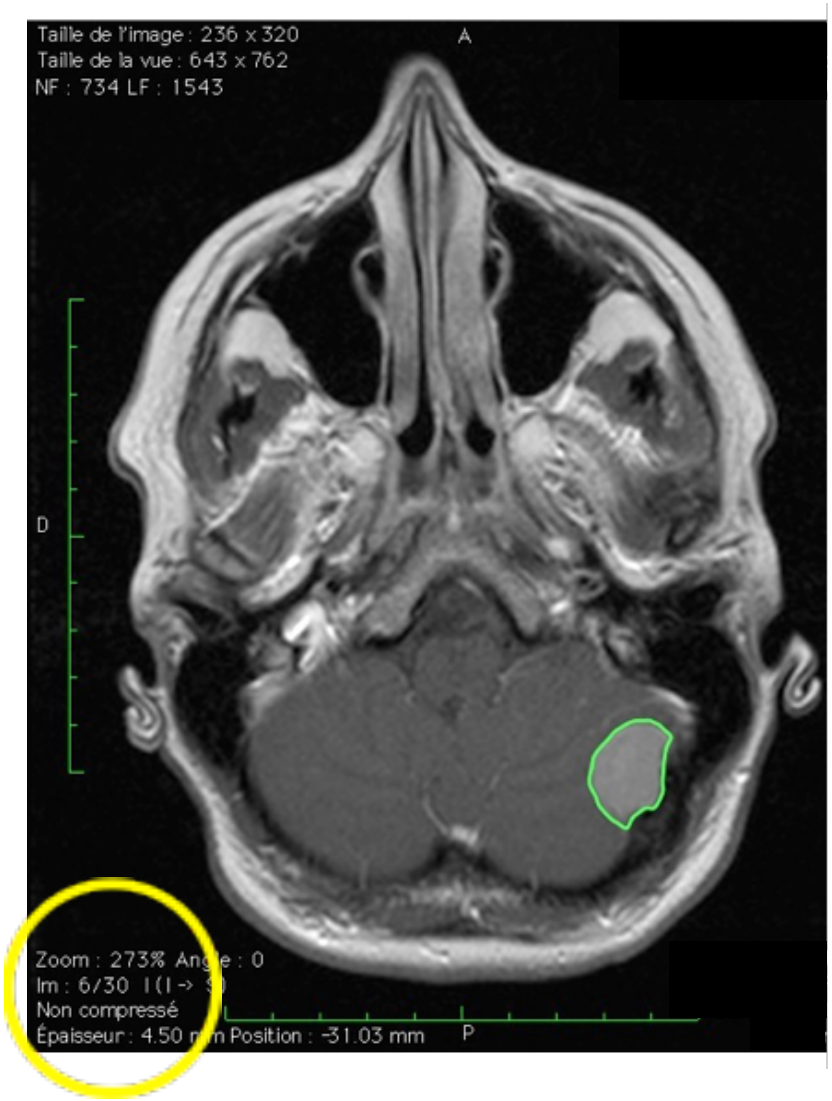


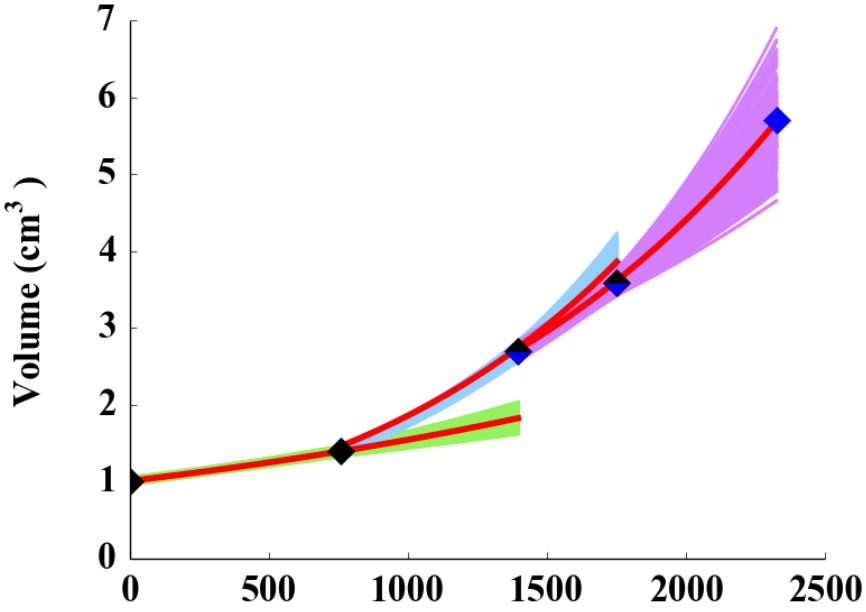


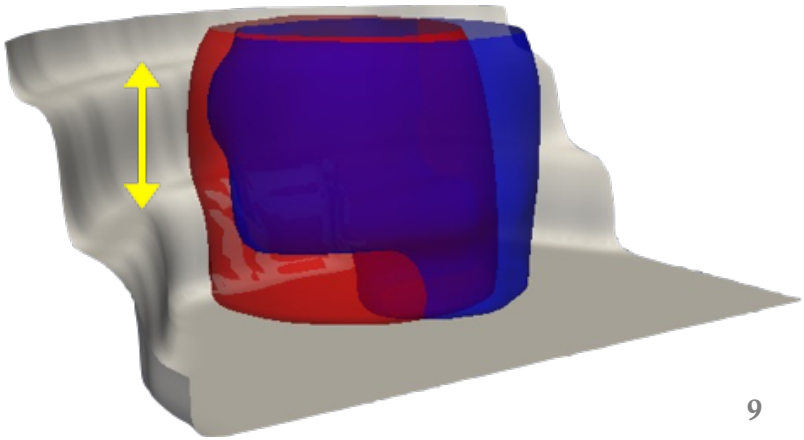


Example

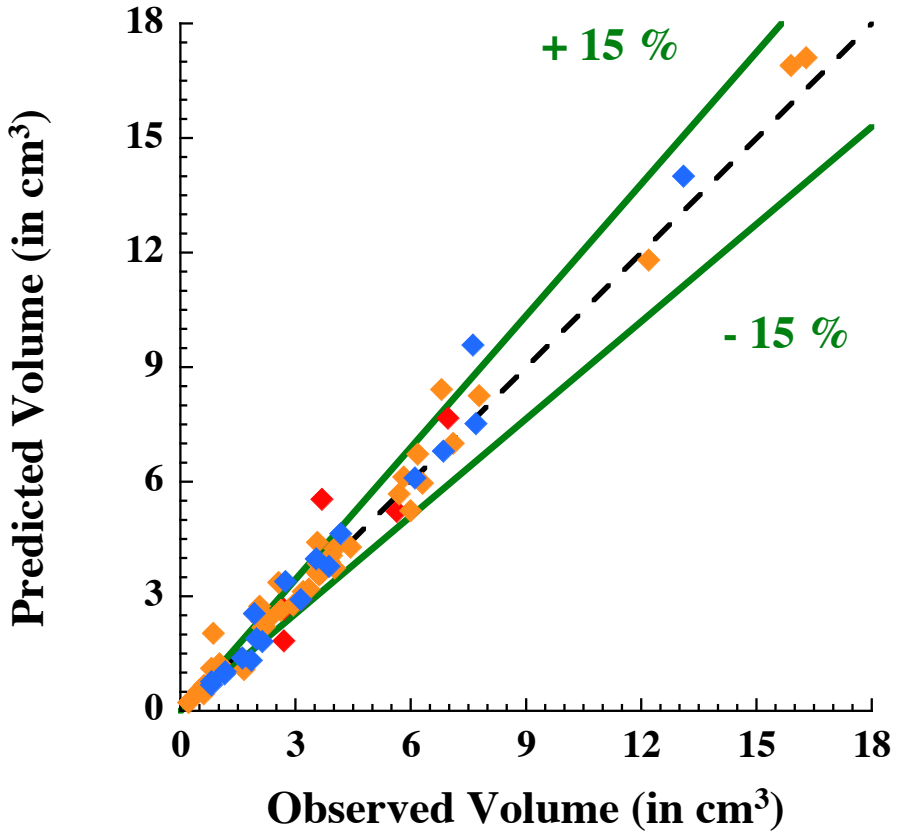
Case #38







Prediction results



Cohort 1:

- 8 patients
- Mean relative error = 14.3%
- Linear regression : $y = -0.23 + 1.10x$ ($R^2 = 0.866$)

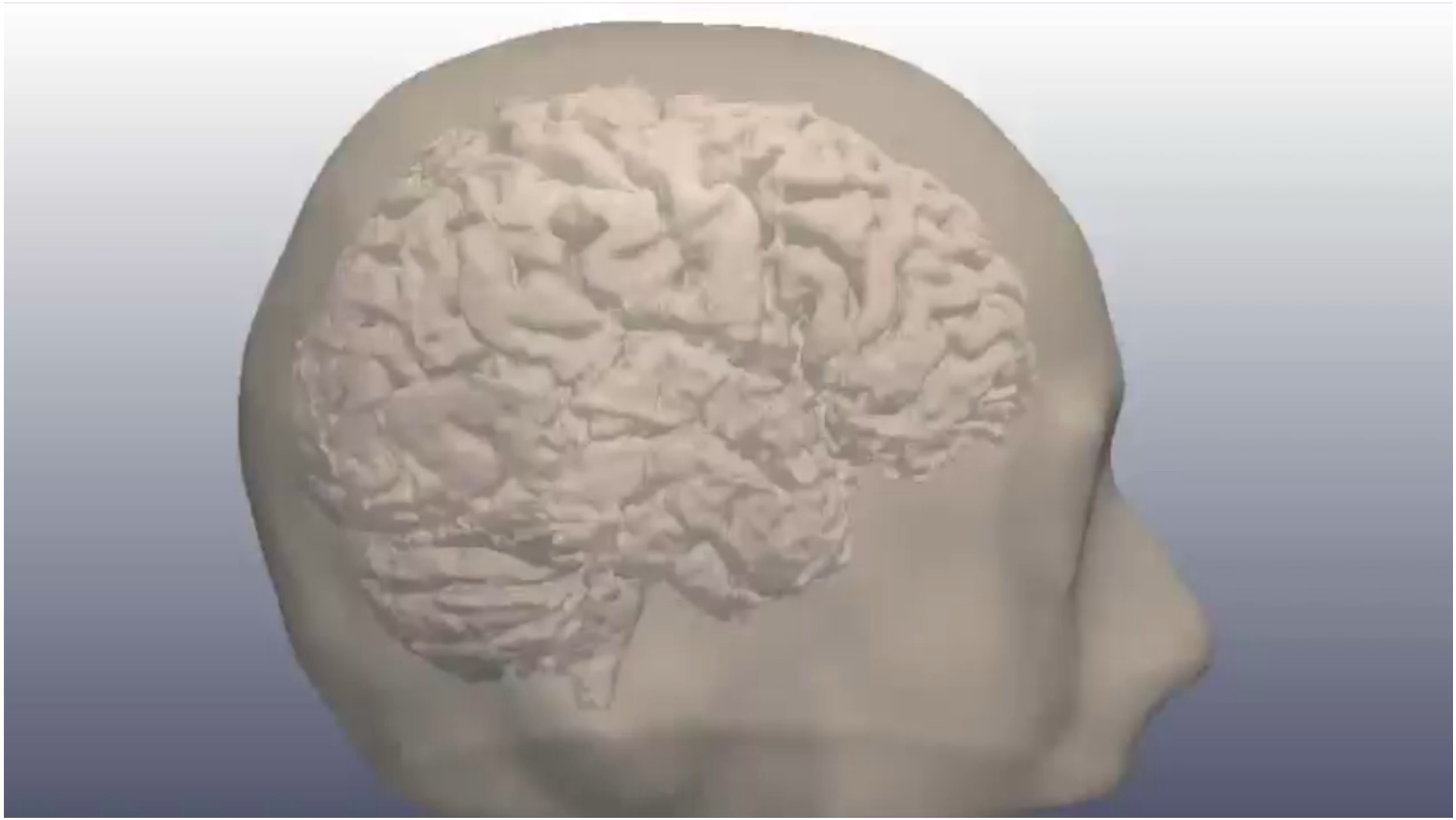
Cohort 2:

- 30 patients
- Mean relative error = 12.7%
- Linear regression : $y = 0.06 + 1.03x$ ($R^2 = 0.986$)

Cohort 3:

- 18 patients
- Mean relative error = 12.6%
- Linear regression : $y = -0.21 + 1.09x$ ($R^2 = 0.980$)

Simulation result



Conclusions

Numerical modeling can improve the monitoring of asymptomatic meningiomas

- Monitoring and prediction of the tumor growth.
- Optimization of the imaging examination frequency.
- Prediction of the brain sensitive structure compression.

A medical software offering segmentation and prediction tools is currently under development