Comparison of T2 and FLAIR MR imaging for target delineation in Glioblastoma: impact on target coverage, normal tissue exposure and pattern of recurrence.

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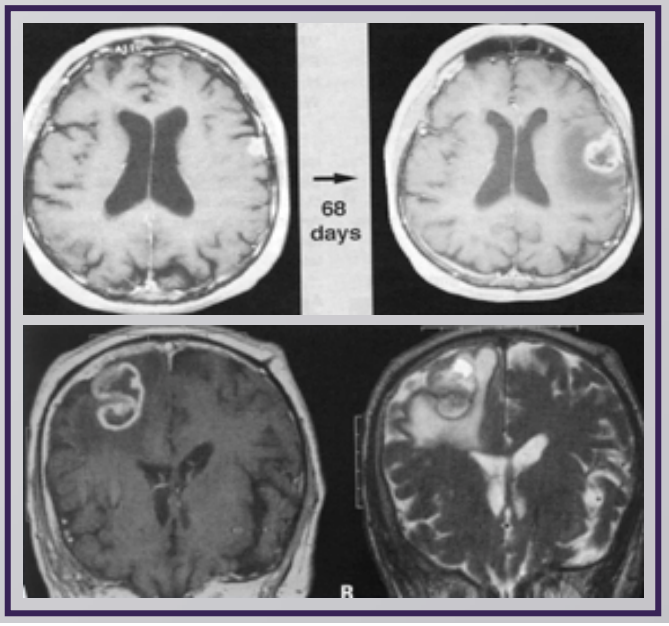
Background

- Glioblastoma Multiforme (GBM) accounts for 70% of new adult cases of malignant brain tumors

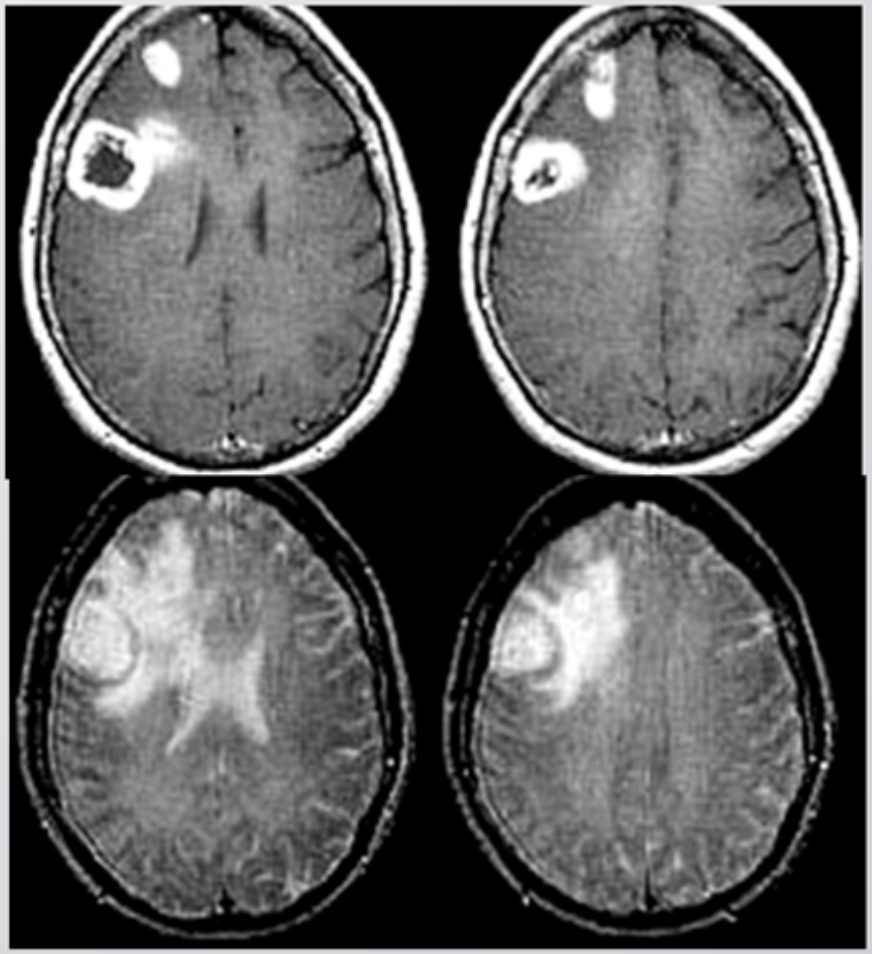
- Standard primary therapy for GBM includes maximal safe resection followed by adjuvant radiation and chemotherapy

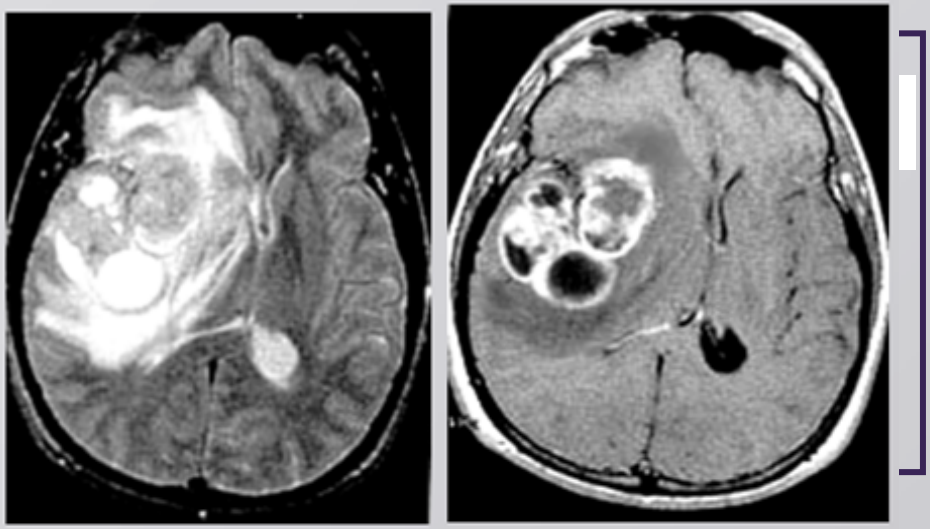
- High recurrence rates (>90%) with a median overall survival (OS) of 15-18 months

- Features of GBM:
  - Rapid progression
  - Enhancing tumor
  - Surrounding oedema (Contains tumor)



Background



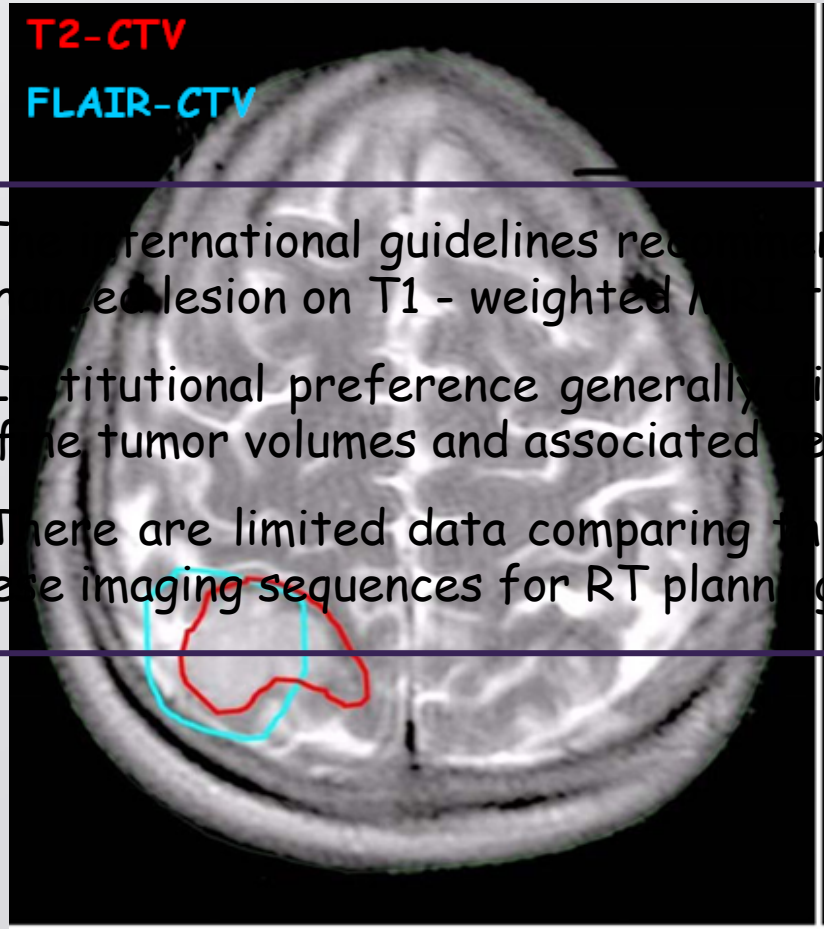


CTV - EORTC: residual tumor and/or resection cavity plus 2 cm without the intentional inclusion of peritumoral edema

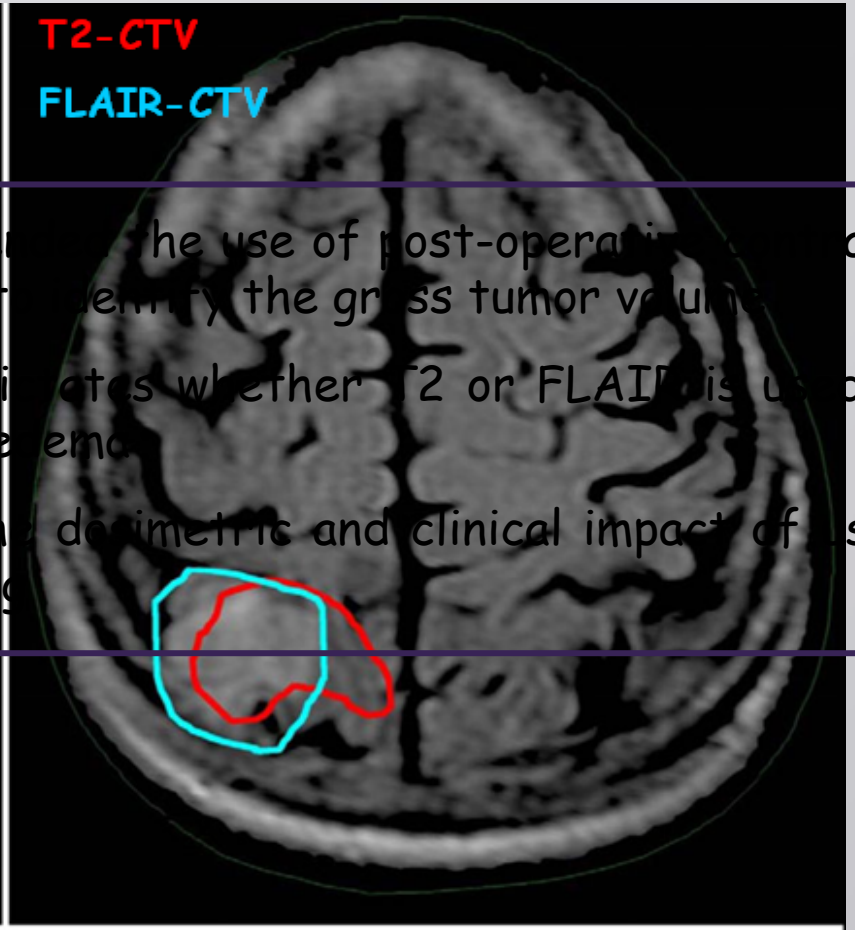
CTV – RTOG: post-operative peritumoral edema plus 2 cm

Background

Current RTOG protocols advise using CT and either FLAIR or T2 images to identify CTV . . . the differences between these sequences have not been clearly defined



T2 weighted MRI



FLAIR MRI

- T[illegible]ternational guidelines rec[illegible]he use of post-operat[illegible]ast-enh[illegible]ed lesion on T1 - weighted M[illegible]entify the gross tumor vol[illegible]
- I[illegible]titutional preference generally i[illegible]ates whether T2 or FLAIR is u[illegible]d to def[illegible]e tumor volumes and associated e[illegible]ema
- T[illegible]here are limited data comparing t[illegible] dosimetric and clinical impact of using the[illegible]e imaging sequences for RT plann[illegible]g

Purpose

The aim of this study is to evaluate the impact on target coverage and normal tissue exposure of FLAIR and T2 weighted MRIs to delineate the surrounding edema for radiation treatment planning in GBM.

Furthermore we analyzed the patterns of recurrence in relation to its peritumoral edema to gain a better understanding of whether peritumoral edema should be intentionally included within the CTV

Methods and Materials

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- We used treatment planning images of adult patients with GBM treated between 2008 and 2012 at the Radiation Therapy Unit-ASMN in whom a complete pretreatment MRI with contrast-enhanced T1, T2 and FLAIR sequences was currently available for review

- All patients were treated with post-operative IMRT and a total dose of 60 Gy in 30 fx and concomitant chemotherapy (TMZ)

- For each patients the MRI scans were fused with the planning CT and used for target definition

- The GTV encompassed the resection cavity and any residual tumor as seen on a contrast-enhancing T1 postoperative MRI

- Delineation of CTV was carried out by adding 2 cm margins to the GTV

- The CTV was expanded by 0.3 cm to create the PTV to compensate for variability in treatment set-up and patient motion

- All patients were followed after RT with MRI scan and recurrence was delineated by neuro-radiologist

Methods and Materials

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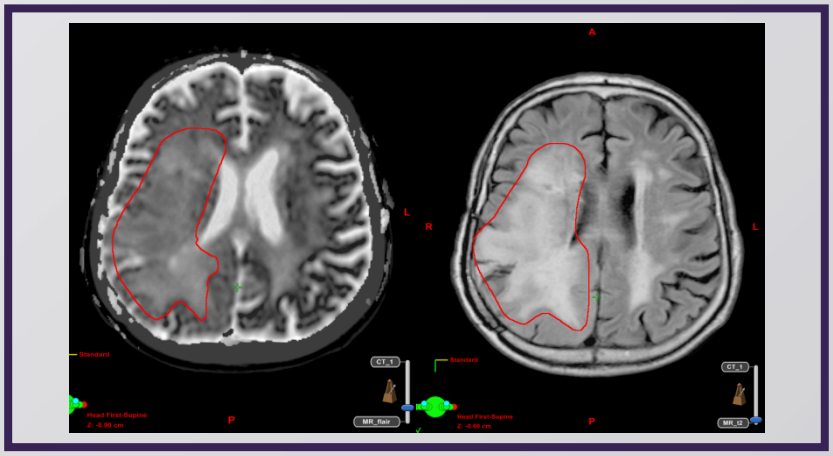
- The CTVs studies were contoured on the T2 (CTV-T2) and FLAIR (CTV-FLAIR) sequences without comparison to the alternative sequence by a single observer



- The PTVs (PTV-T2 and PTV-FLAIR) were created with a standard 0.3 cm volumetric expansion
  - Using the "calculate volume" function, the CTVs and PTVs in cc were recorded
  - The differences between the CTVs/PTVs were tabulated and a mean percent difference was calculated
  - The *Dice coefficient* (defined as the volume of overlap between two sets of contour, divided by their mean volume) was calculated to evaluate overlap between the CTVs/PTVs

Methods and Materials

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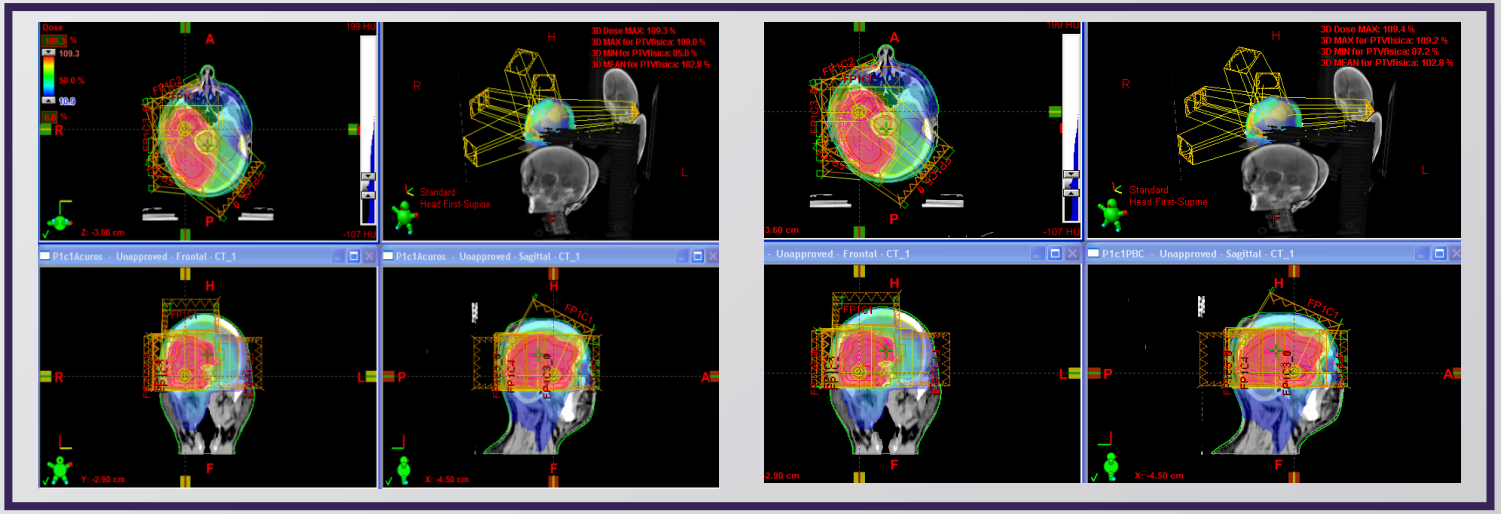
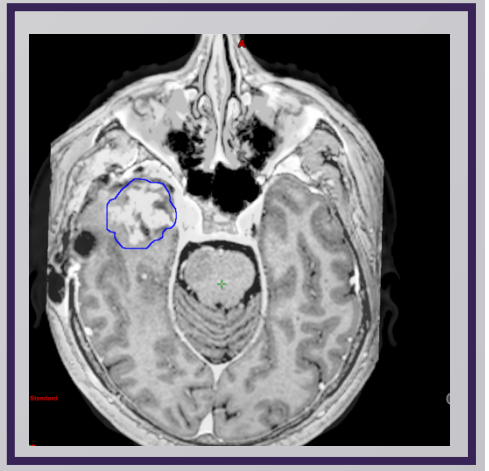
- For each patients two IMRT plans were calculated for PTV-T2 and PTV-FLAIR to evaluate the potential consequences in respect to target coverage and normal tissue exposure using the PTVs generated with different MRI sequences



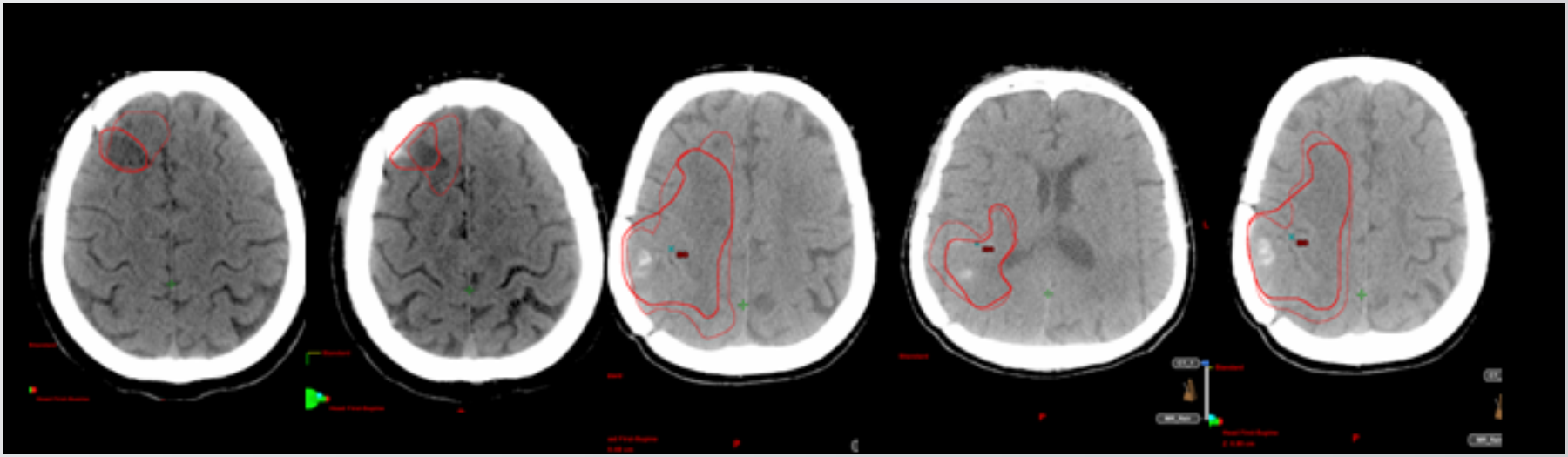
- Pattern of recurrence in terms of their relationship to the tumor volumes delineated using the different MRI sequences was evaluate for each patients



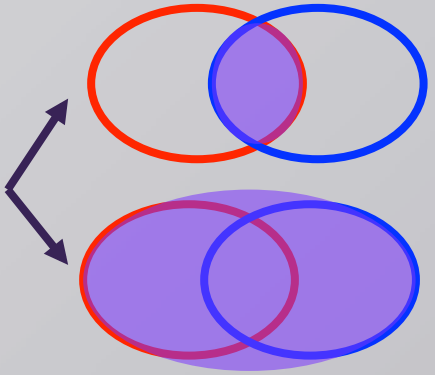
Results

… to date were evaluated 34 cases

- The CTV_{T2} volumes and CTV_{FLAIR} were significantly different (p=0.03)



- The CTV_{FLAIR} volumes were significantly larger than CTV_{T2} (p=0.04):
  - mean volumes = 84.181 cc *vs* 77.535 cc
  - mean percent deviation between CTV_{FLAIR} and CTV_{T2} = 25%
  - average **overlap** volume between CTV_{FLAIR} and CTV_{T2} = 54.6 cc
  - average **union** volume between CTV_{FLAIR} and CTV_{T2} = 80.57 cc
  - Mean Dice Coefficient = 0.74

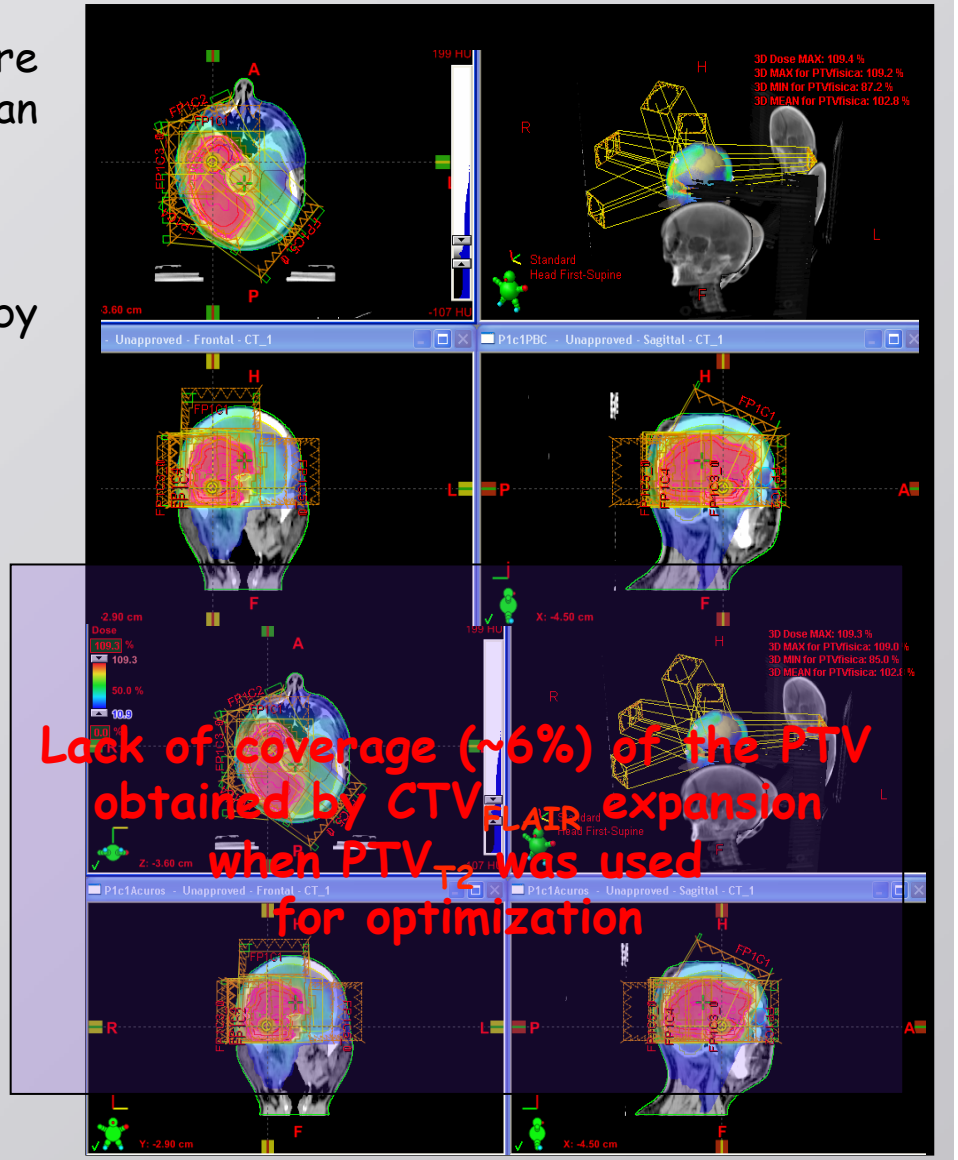


Results

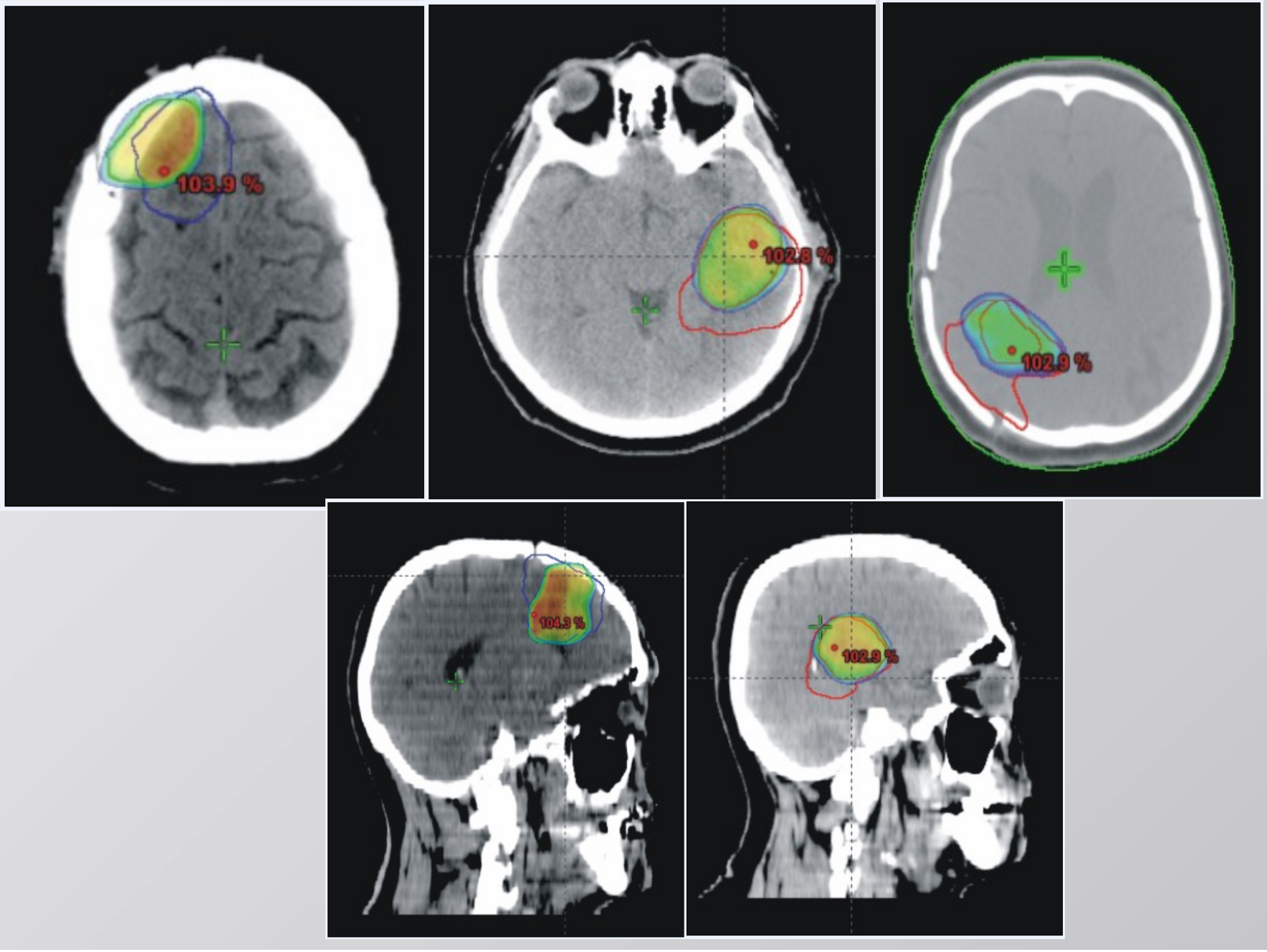
- The PTV_{T2} volumes and PTV_{FLAIR} were significantly different (p=0.03), with a mean volumes of 173 and 191.2 cc, respectively

- For each pt two **IMRT plans** were created by optimization on PTV_{T2} and PTV_{FLAIR} :

Parameters	PTV_{FLAIR}	PTV_{T2}	*p*
T2 IMRT plan			
V95 cc	99.8	99.9	*n.s.*
D98 Gy	47.79	59.8	*0.02*
D2 Gy	63	63.2	*n.s.*
CI	0.71	0.76	*n.s.*
FLAIR IMRT plan			
V95 cc	99.9	99.9	*n.s.*
D98 Gy	59.7	59.8	*n.s.*
D2 Gy	63.1	63.27	*n.s.*
CI	0.83	0.62	*n.s.*



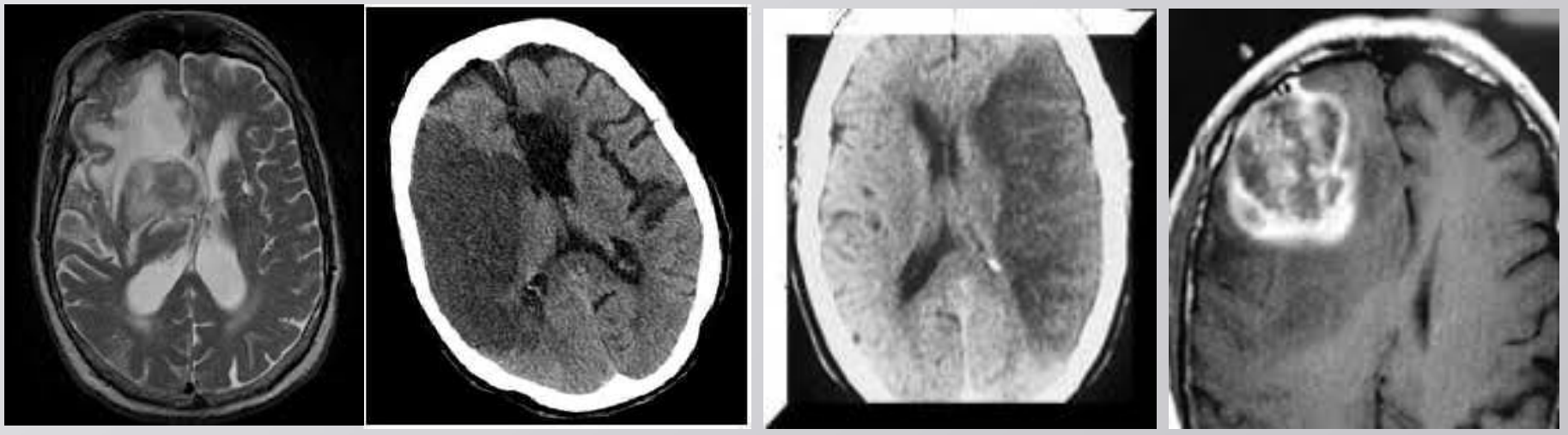
Example



Results

- The median volume of brain irradiated to 60 Gy according to plan type was significantly higher for original plan compared with the FLAIR and T2 plans (p=0.001)

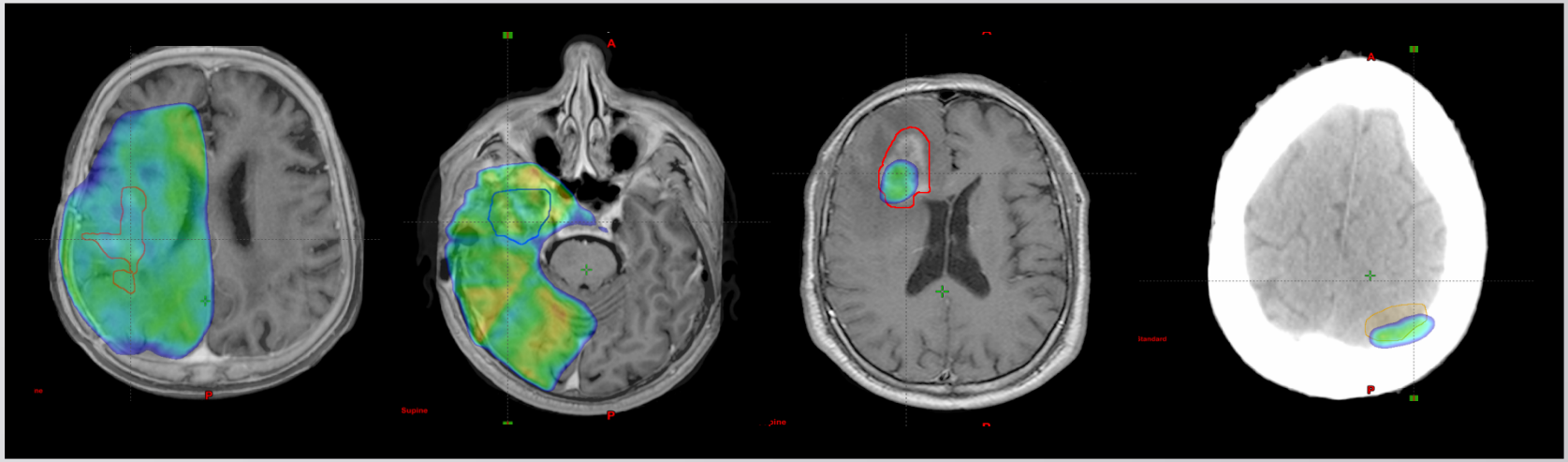
- However for pts with peritumoral edema > 75 cc the median percent volume of brain irradiated to 60 Gy was similar in the three groups



Results

Recurrence was defined as:

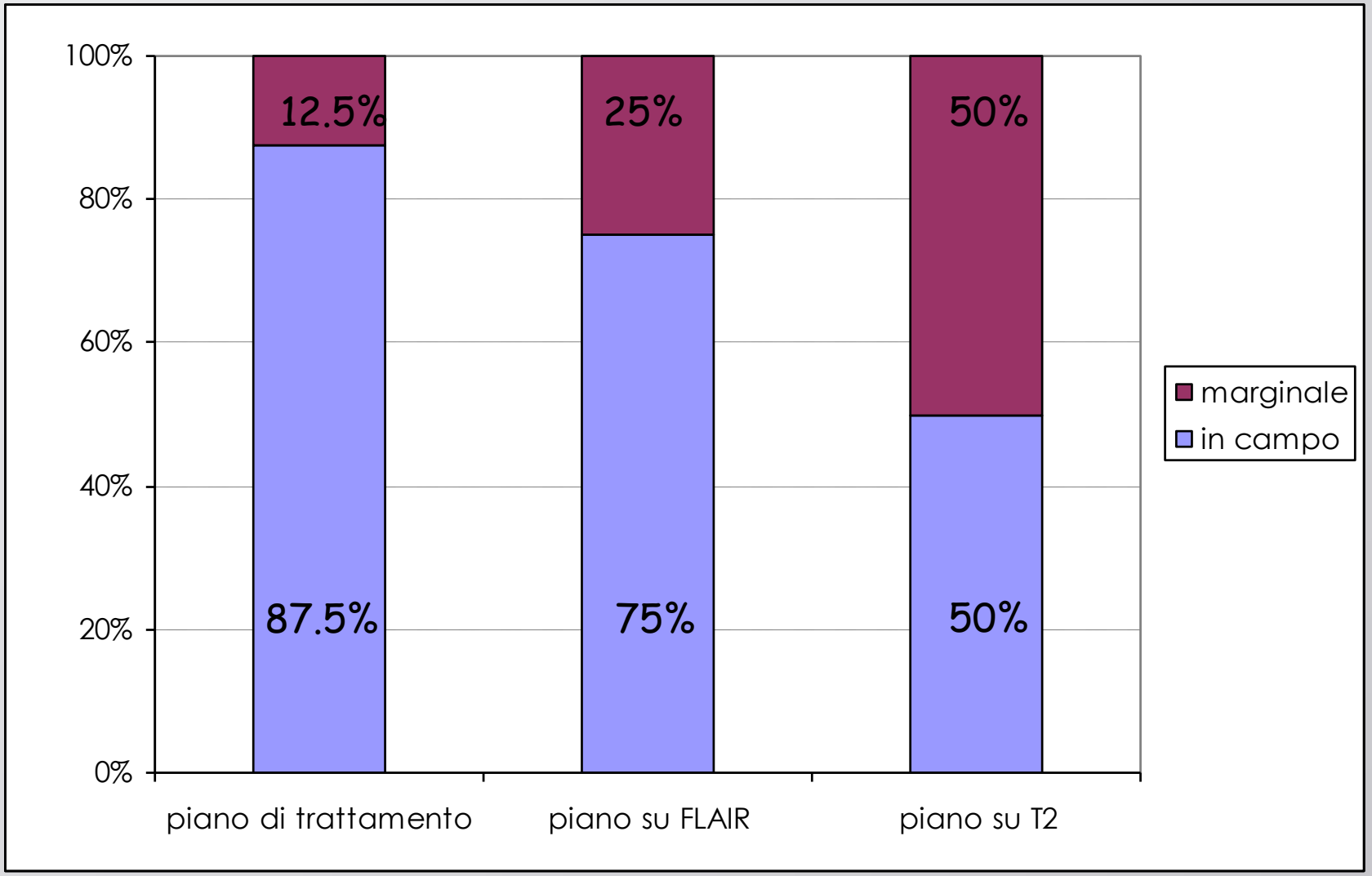
- "**in field**" if more than 95% of the recurrence volume was in 95% isodose line of 60 Gy;
- "**marginal**" when less than 95% of the recurrence volume was outside the high dose volume;
- "**distant**" when recurrence was outside the RT field (<20% isodose line).



30 pts (88%) failed in central or marginal localization

Results

Distribution of the Recurrence Volume (RV) with different plans



Conclusions

- Based on our comparison of T2 and FLAIR imaging for radiation treatment planning, both techniques are important and not interchangeable

- Each technique can help distinguish normal parenchyma from edema and abnormal tissue

- Until we have sufficient imaging to determine where a recurrence is most likely to occur, the use of a statistical margin that accounts for the pattern of failure of GBM within 2 cm of the primary tumor is supported

Thank you !