

Leksellův gama nůž

principy

indikace

kontraindikace

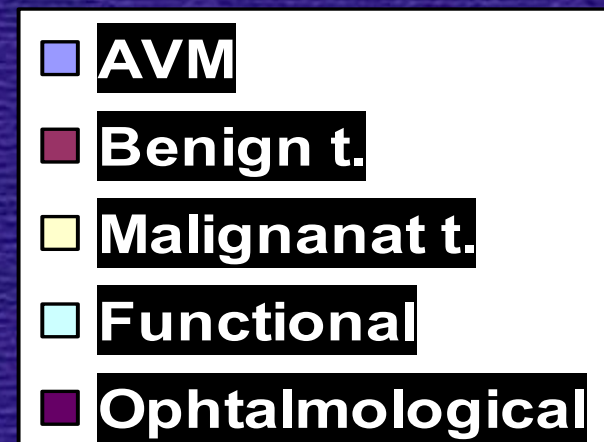
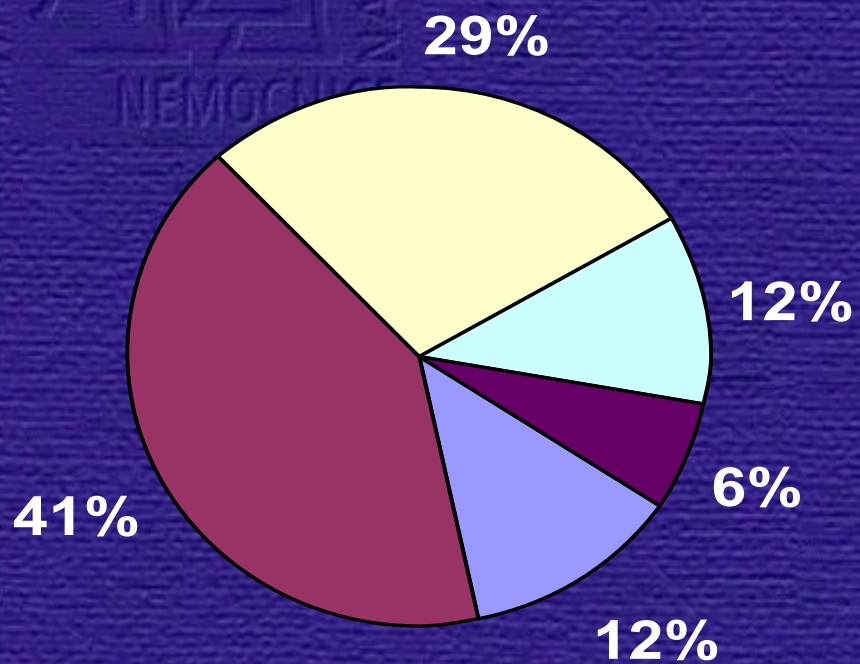
kontroverze

- imaging (MR,PET)
- radiation technology

radiobiology

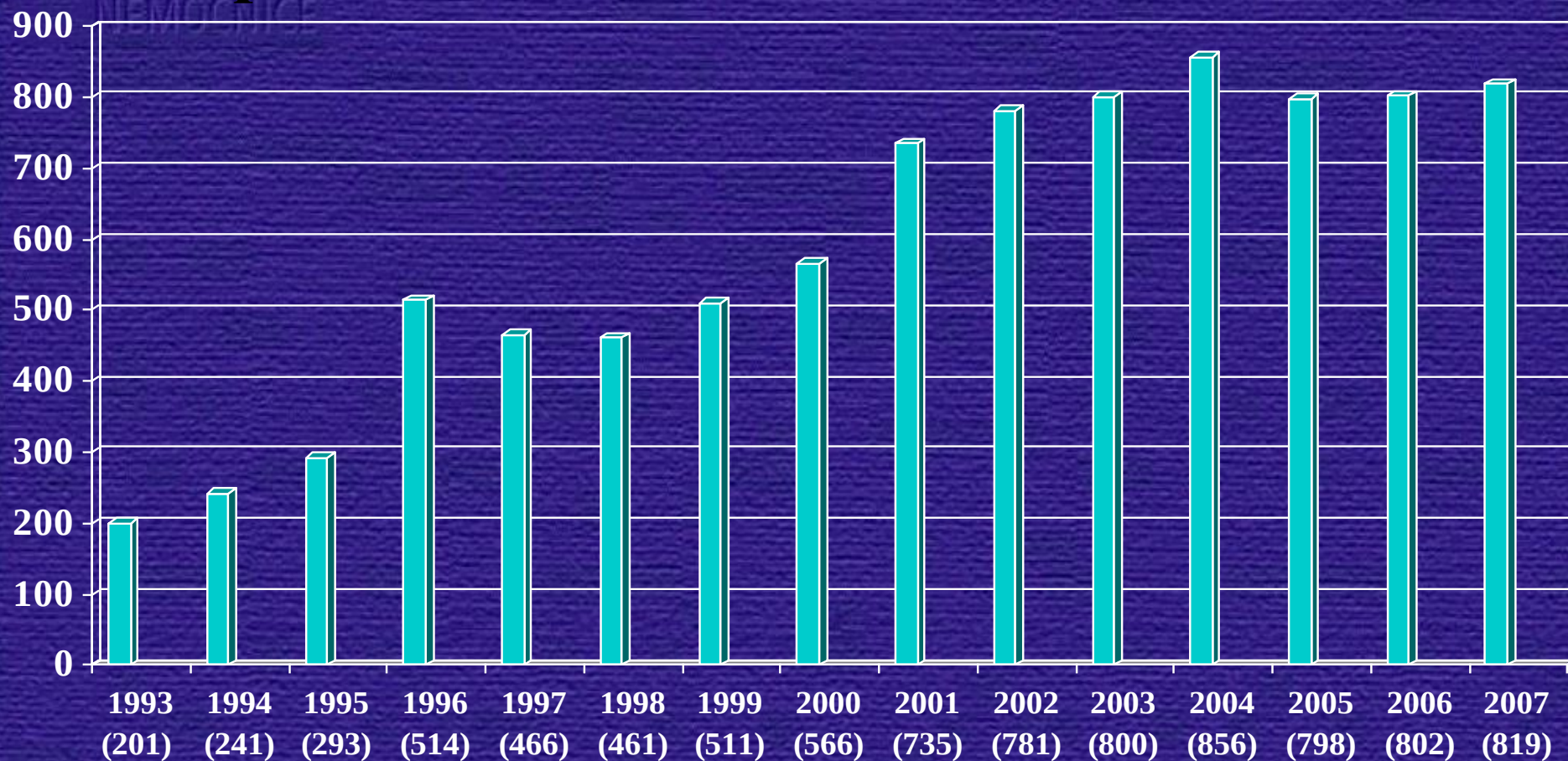
radiosurgery
(single high dose)

stereotactic radiotherapy
(fractionation scheme)



26.10.1992-31.12.2007

8844 procedures



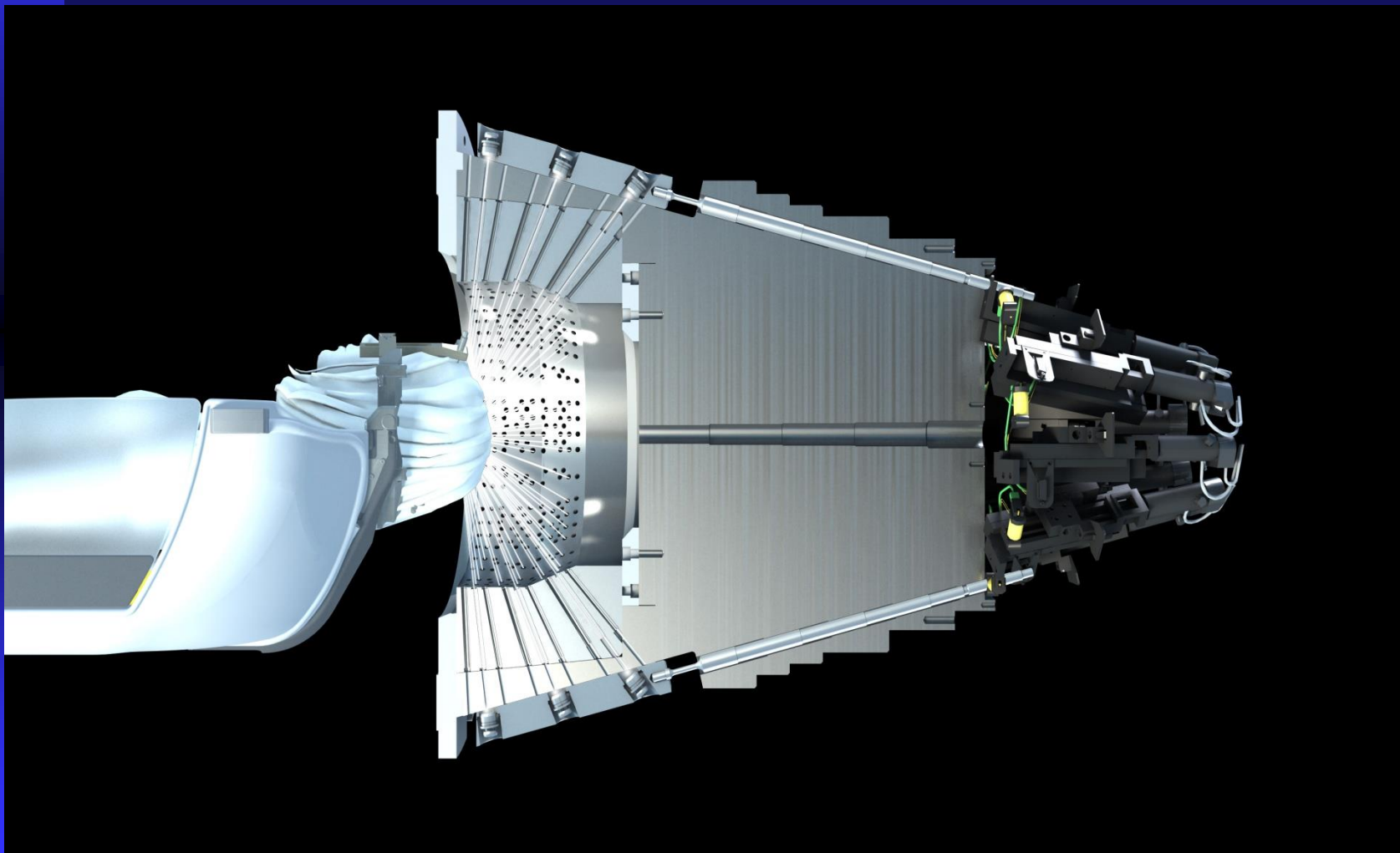
LGK represents 8-10% of all brain surgeries in CR

Počty pacientů od 26. 10. 1992 do 31. 12. 2012

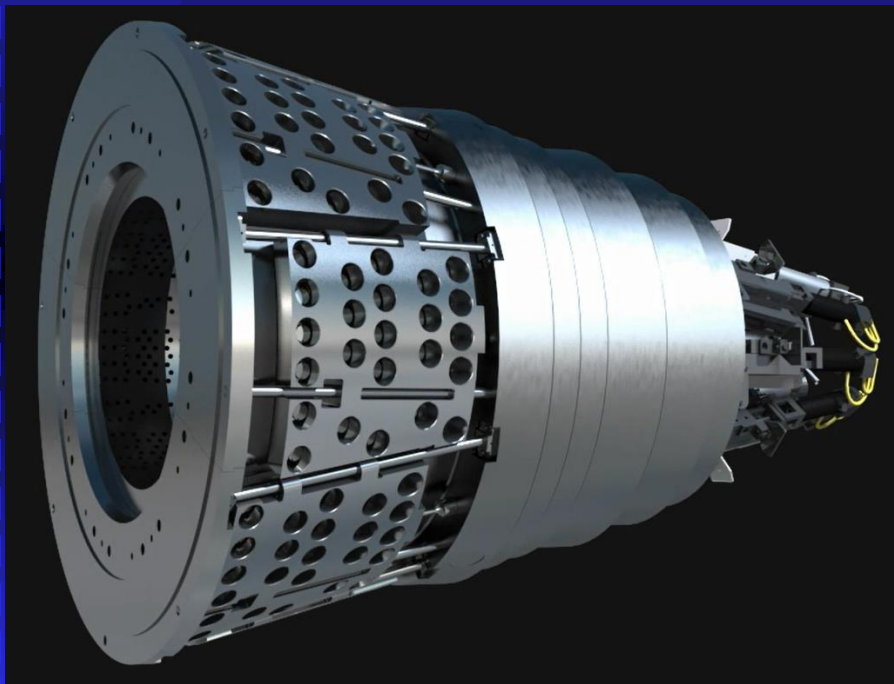
AVM	1082
Neurinom akustiku	1314
Meningeom	2399
Adenom hypofýzy	1056
Pinealom	35
Kraniofaryngeom	60
Chordom	44
Chemodektom	79
Metastáza	3299
Gliální tumor	339
Uveální melanom	323
Neuralgie n V.	1221
ostatní	906
celkem	12006 pacientů / 13522 operací



Kolimační systém LGK



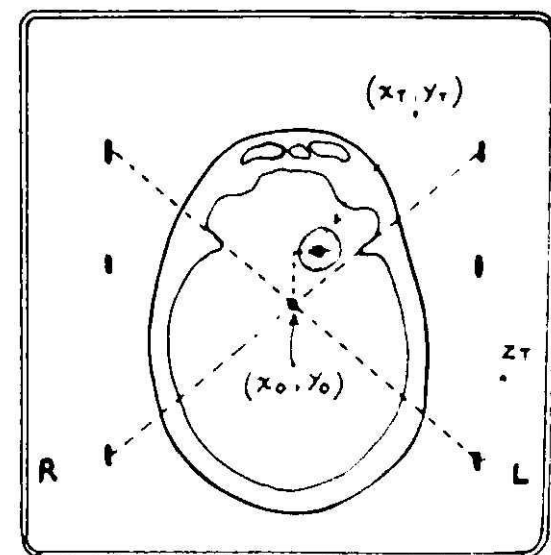
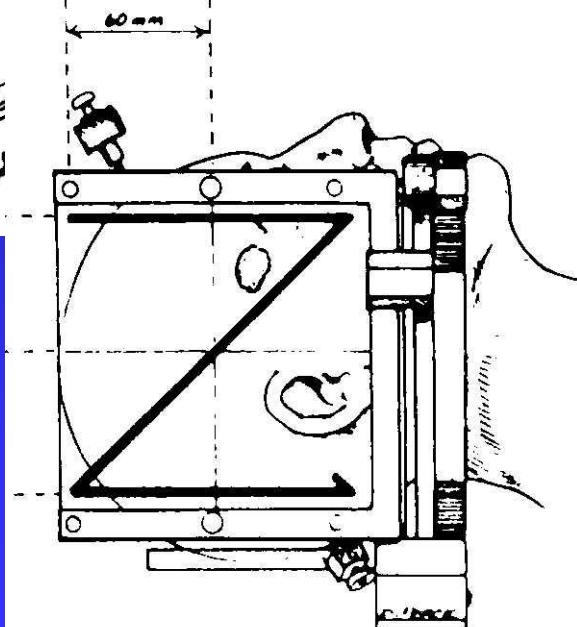
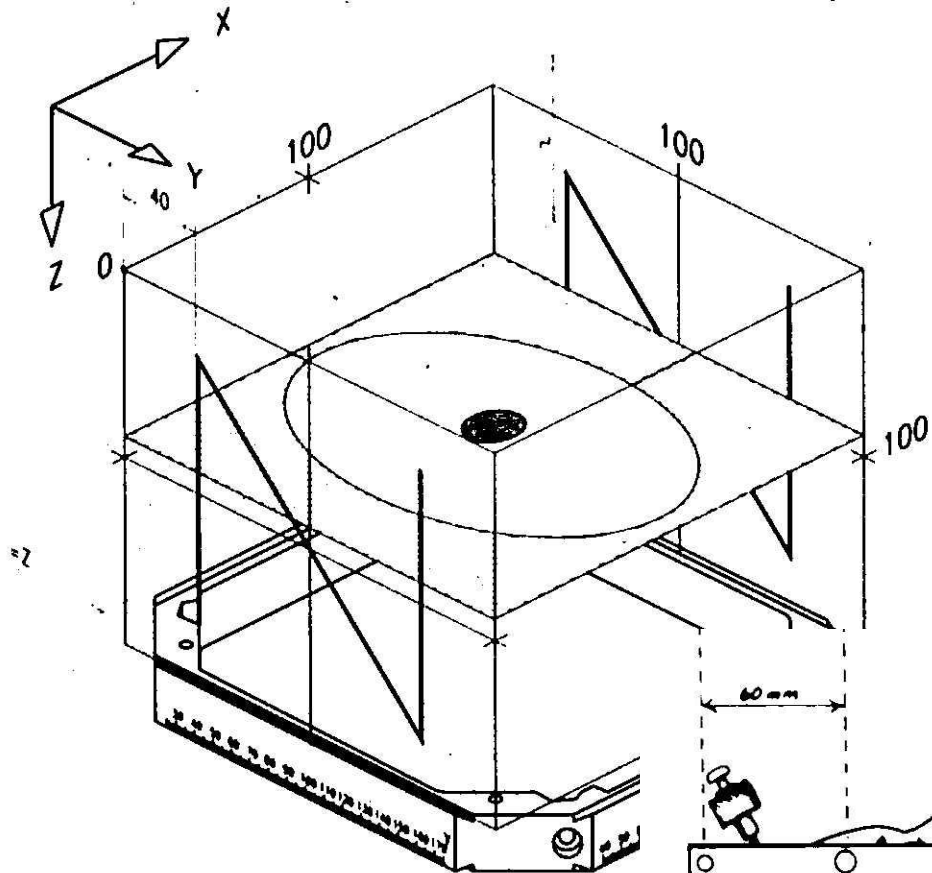
Kolimační systém Perfexion



System EXTEND pro model PFX

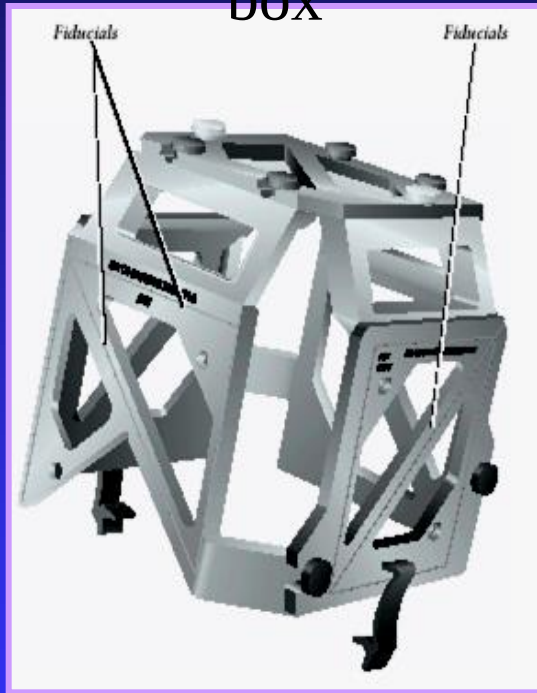




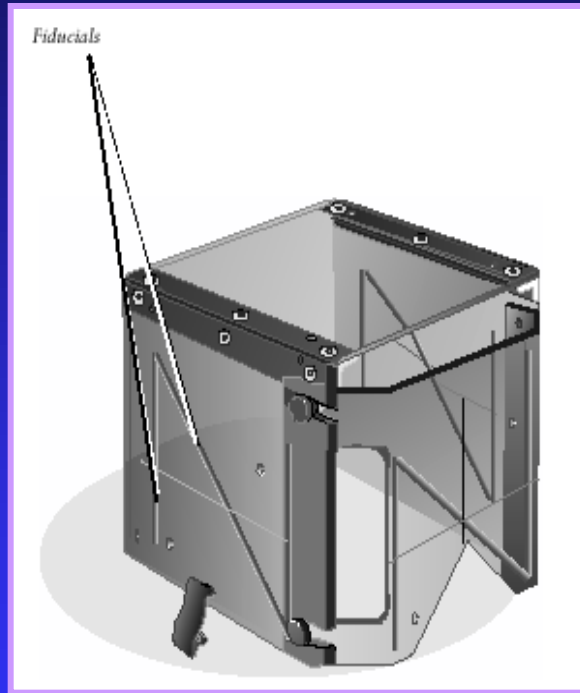


Stereotactic target localization

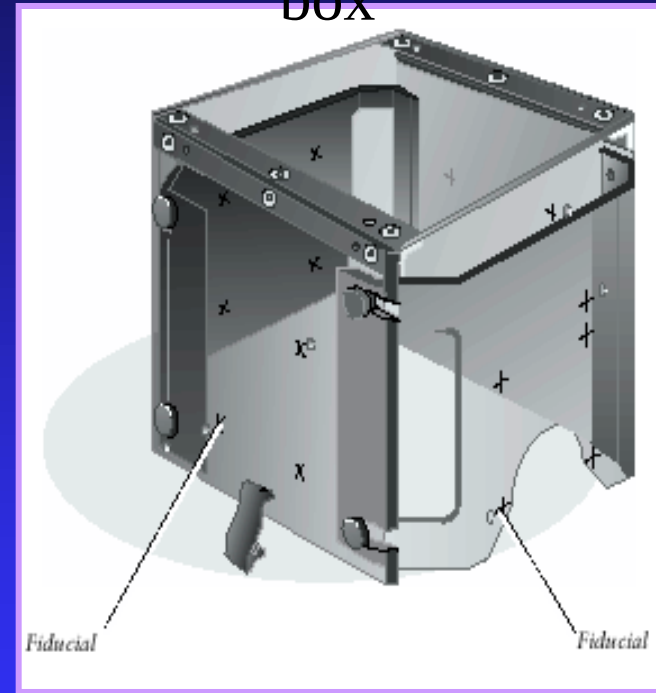
MR indicator
box

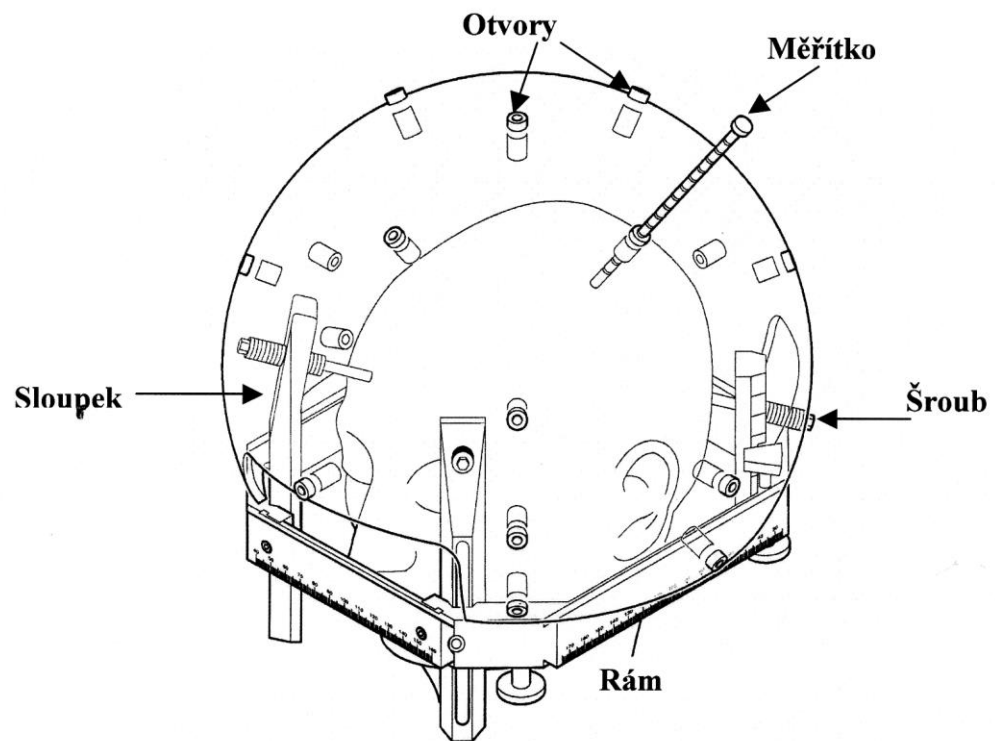


CT indicator box



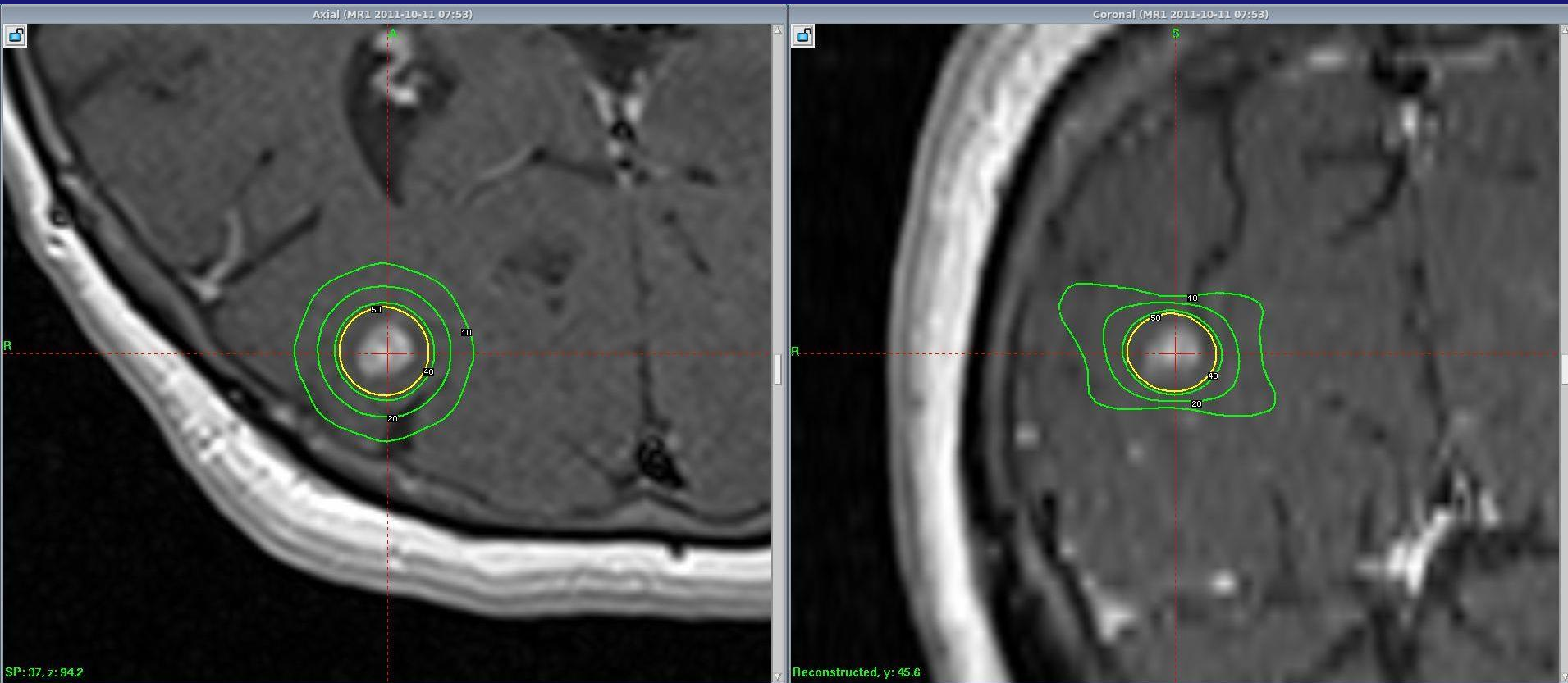
DSA indicator
box

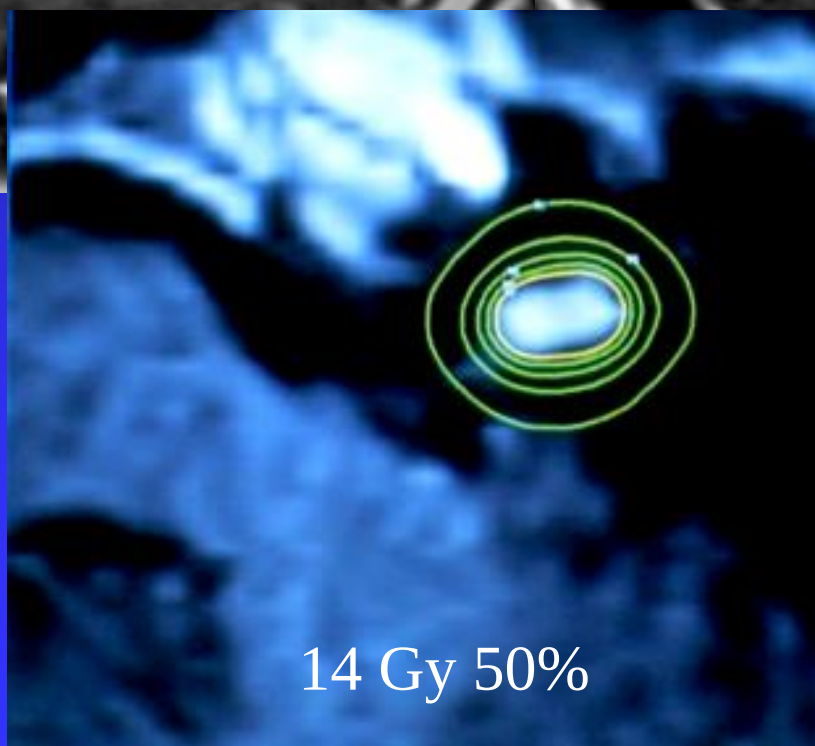
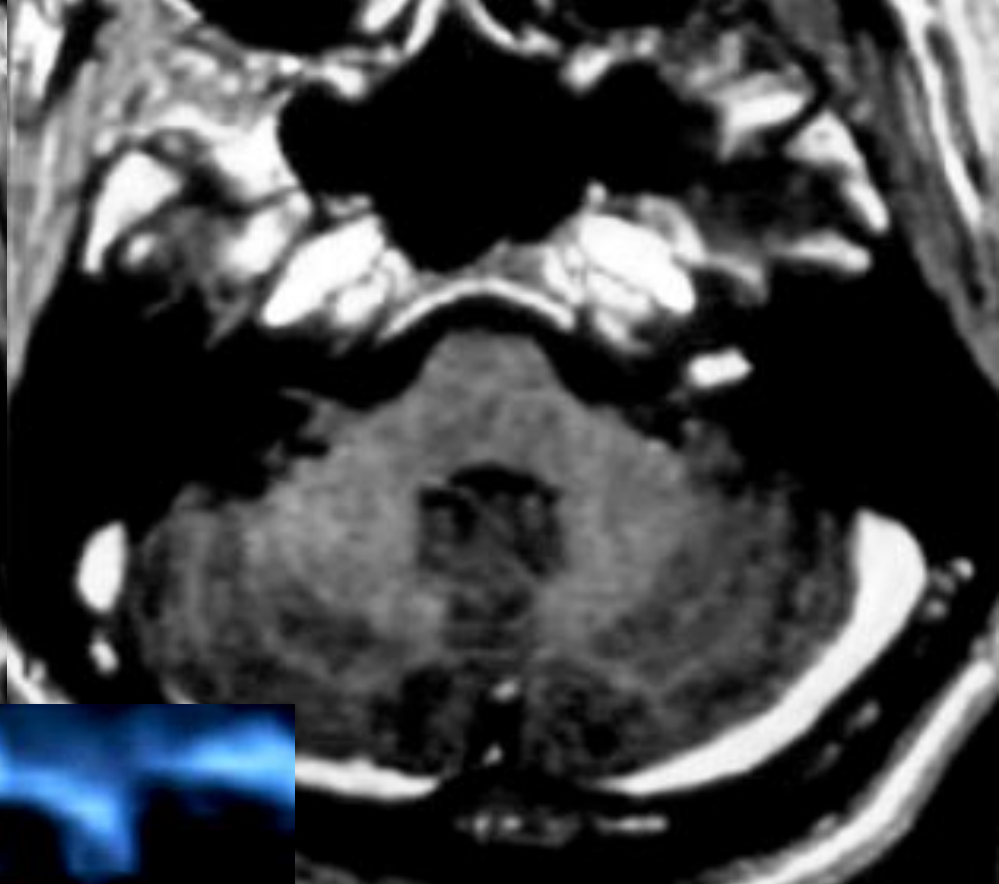
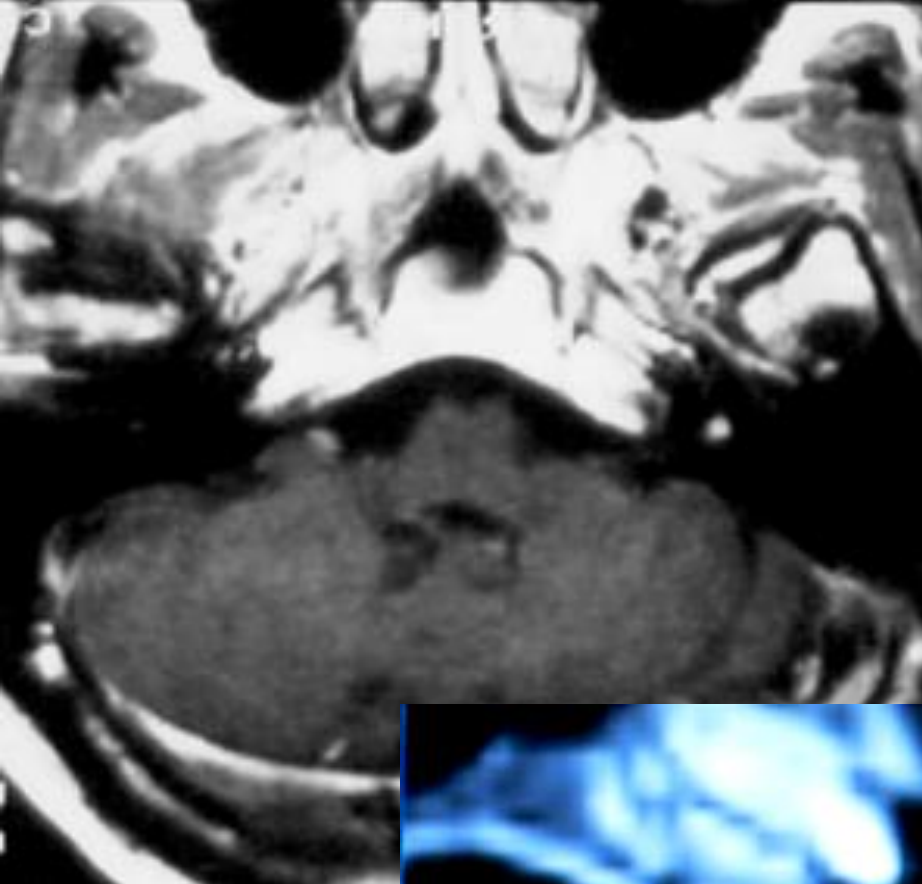




■ Melanoma meta

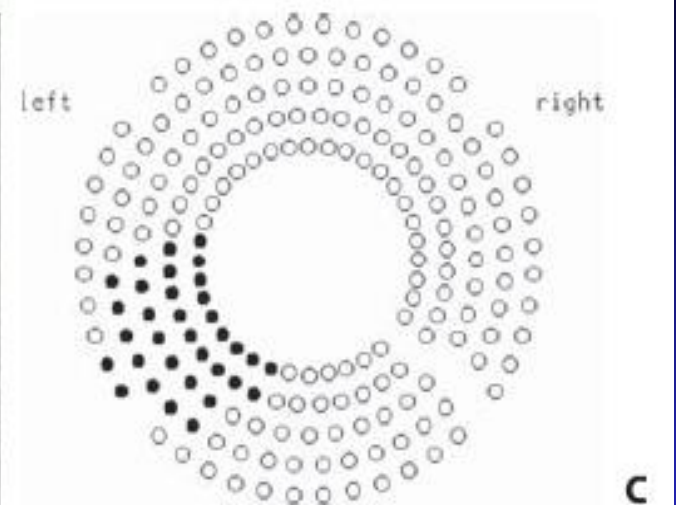
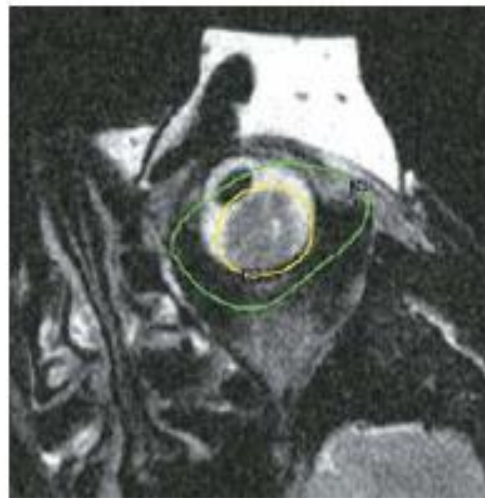
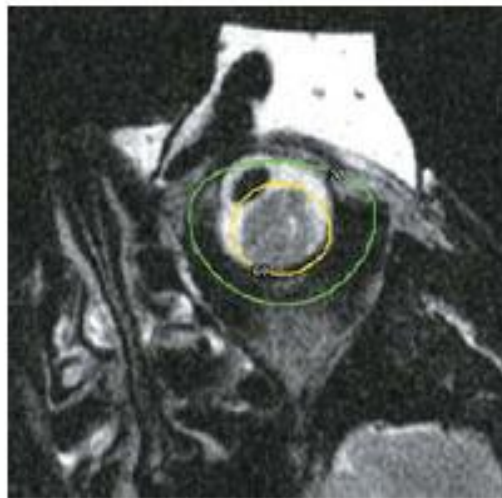
50,40,30,20,10 % isodose curves



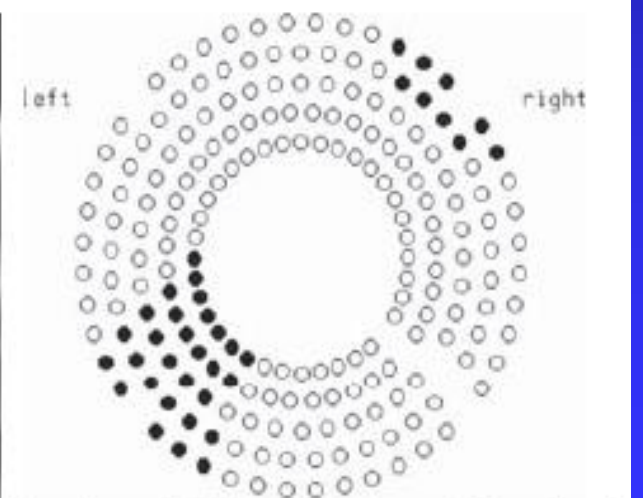
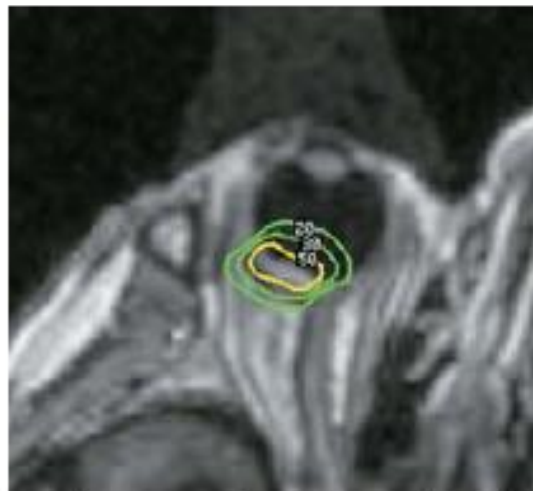
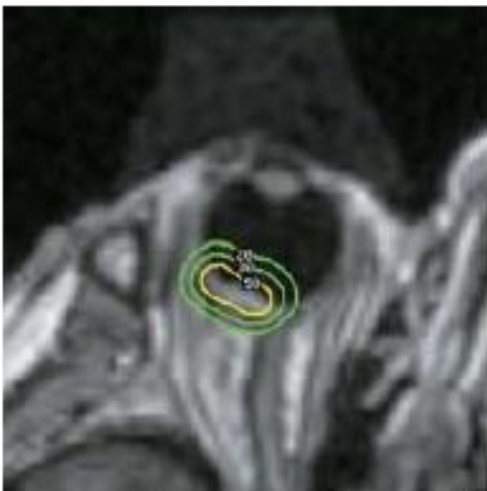


Acoustic nerinoma

14 Gy 50%

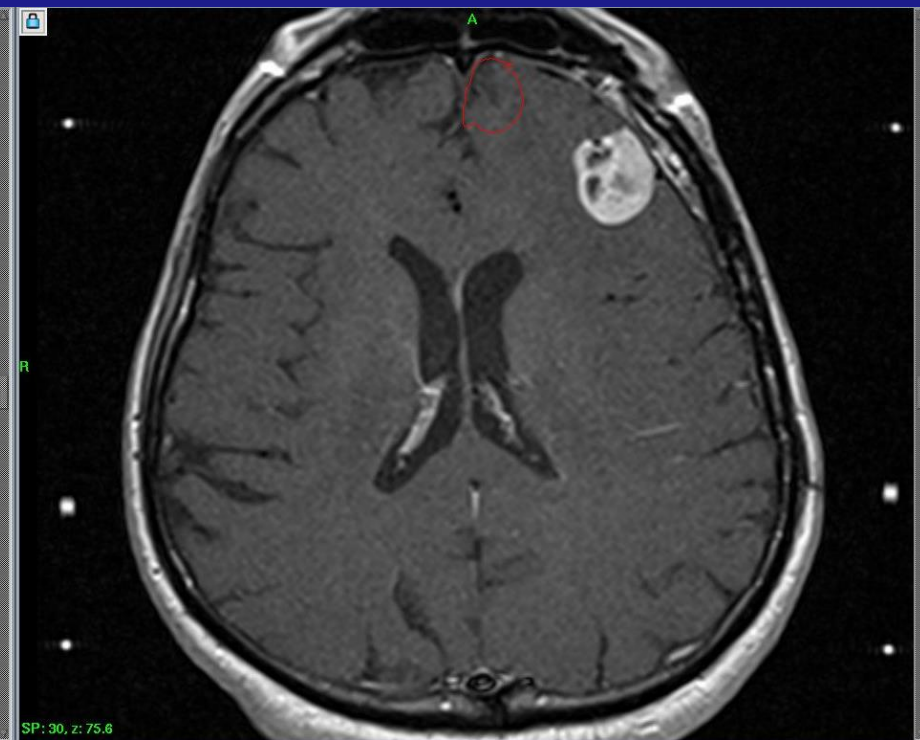
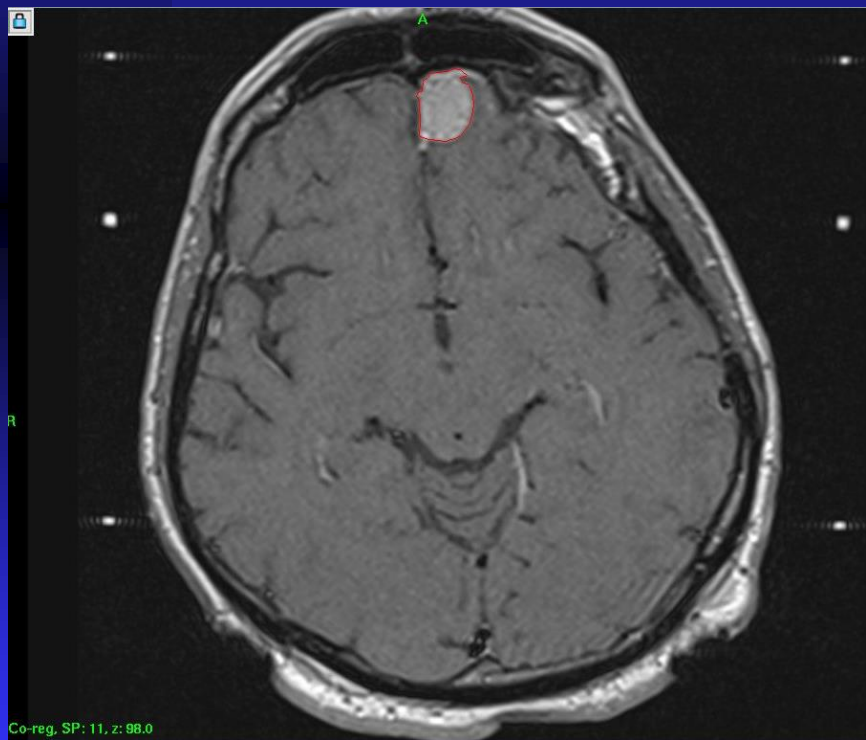


C



Anaplastický meningiom-vícečetné léze koregistrace s předchozím vyšetřením (I.ozáření na LGK)

16 měsíců po ozáření



Toxicity

RTOG/EORTC

Acute toxicity (0-90 days after treatment)

Late toxicity (91 days - 5 years.,WHO recommendation)

**Very late toxicity(secondary malignant tumors)
(10-15 years after irradiation)**

Tolerance doses (critical structures)

lens 2-3 Gy

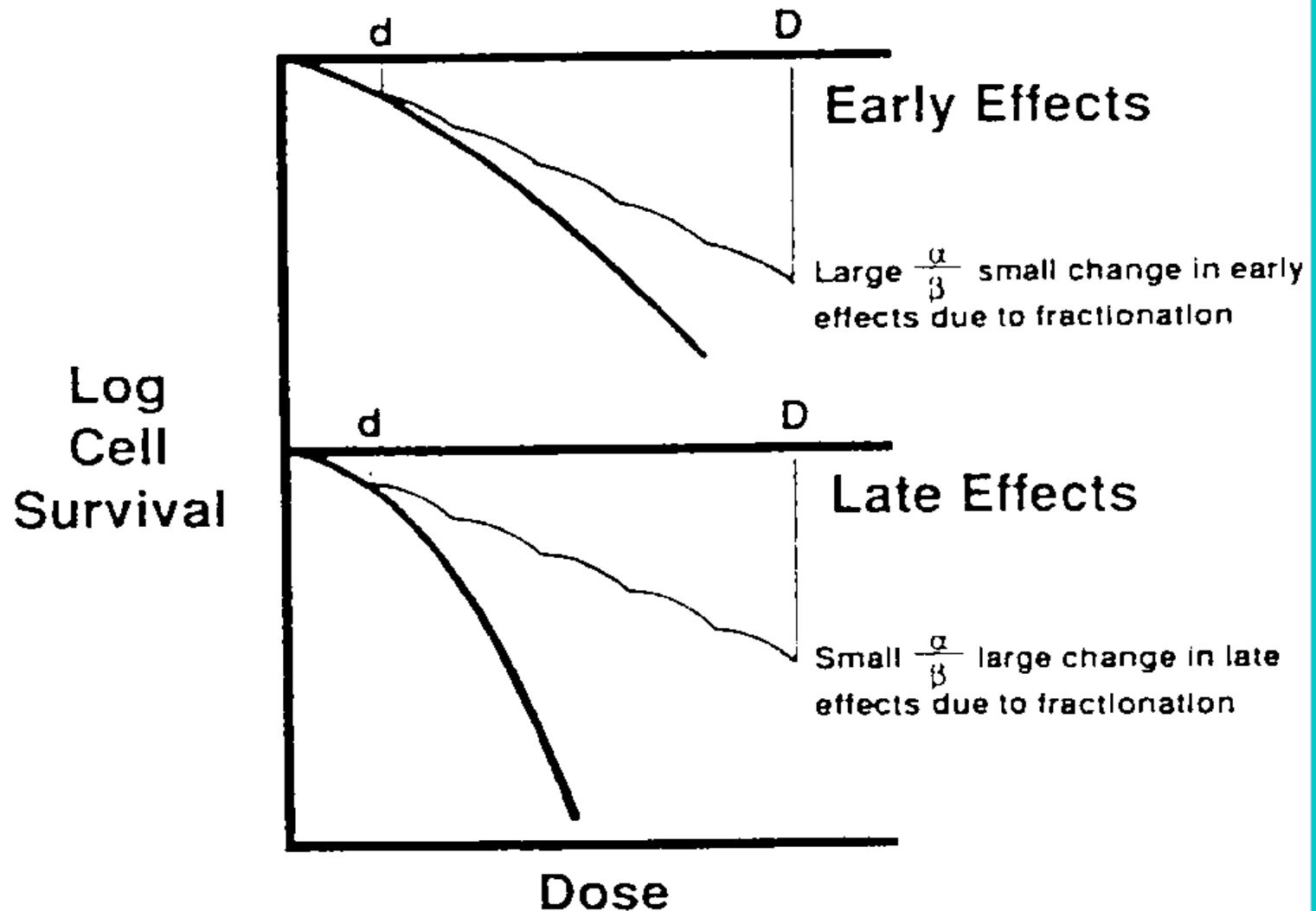
optic pathway 8-10 Gy

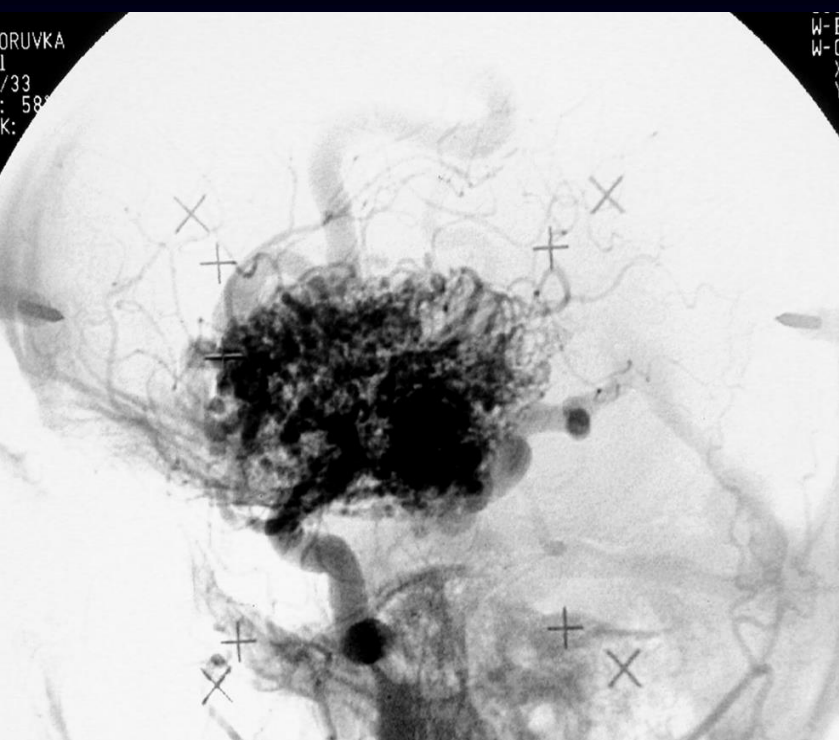
brain stem 12-14 Gy

cranial nerves 14-18 Gy

pituitary gland 15 Gy

Survival curves for fractionation





Benign tumors

- meningioma

12-16 Gy

- pituitary adenoma

- vestib. Schwannoma

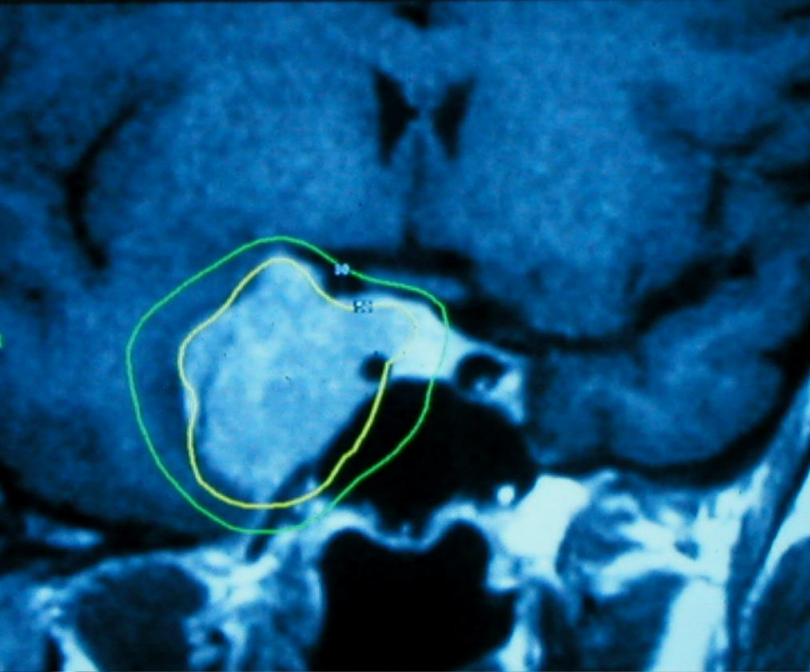
12-14 Gy

- chemodectoma
- schwannoma
- craniophar.
- chordoma
- pinealom
- others

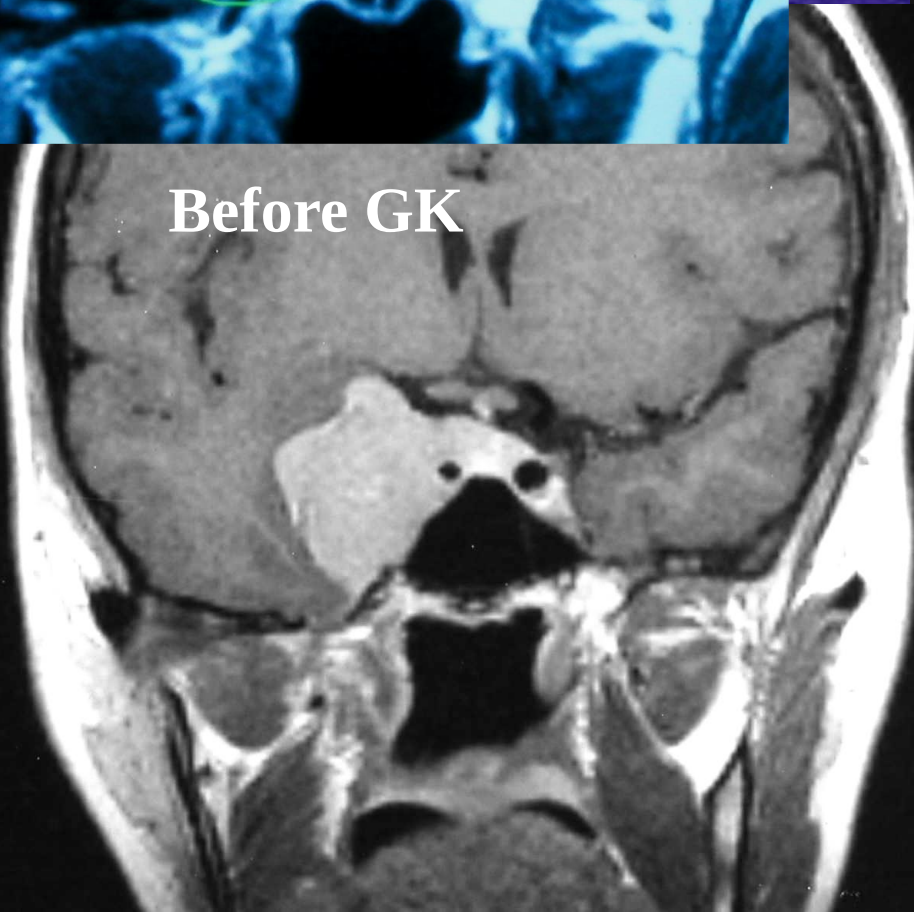
Meningioma

Female 47 y.

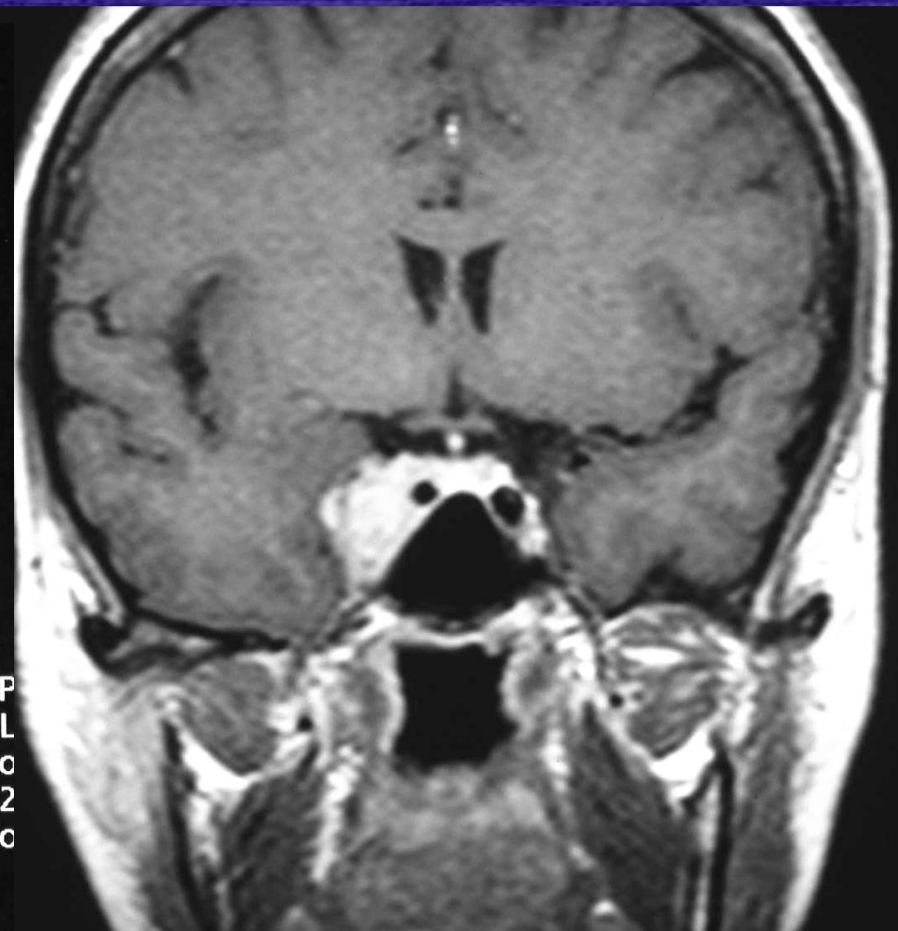
4 y. after GK



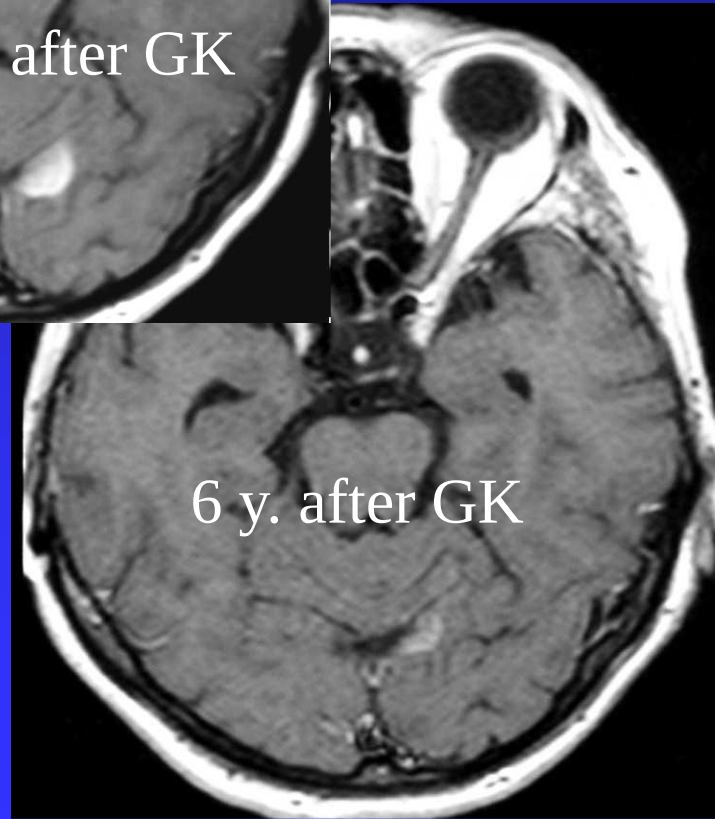
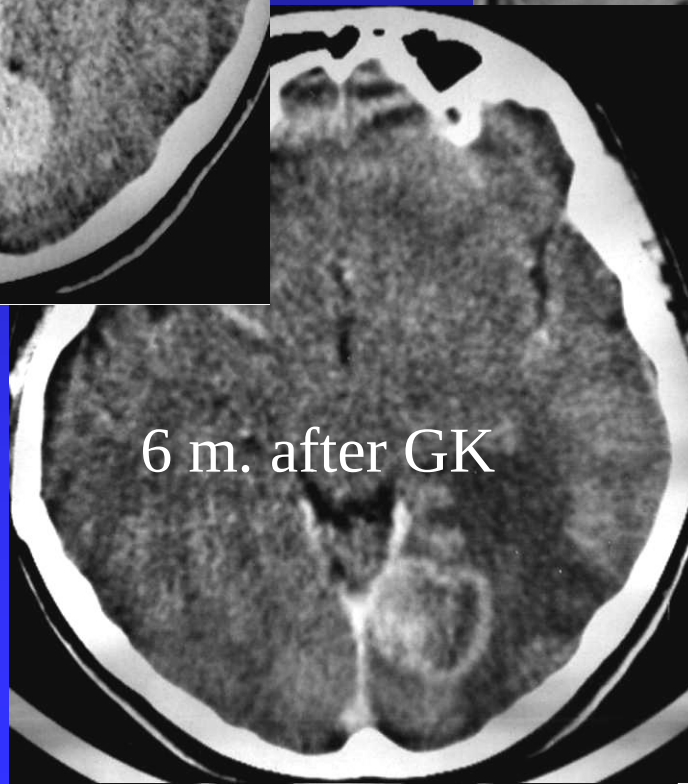
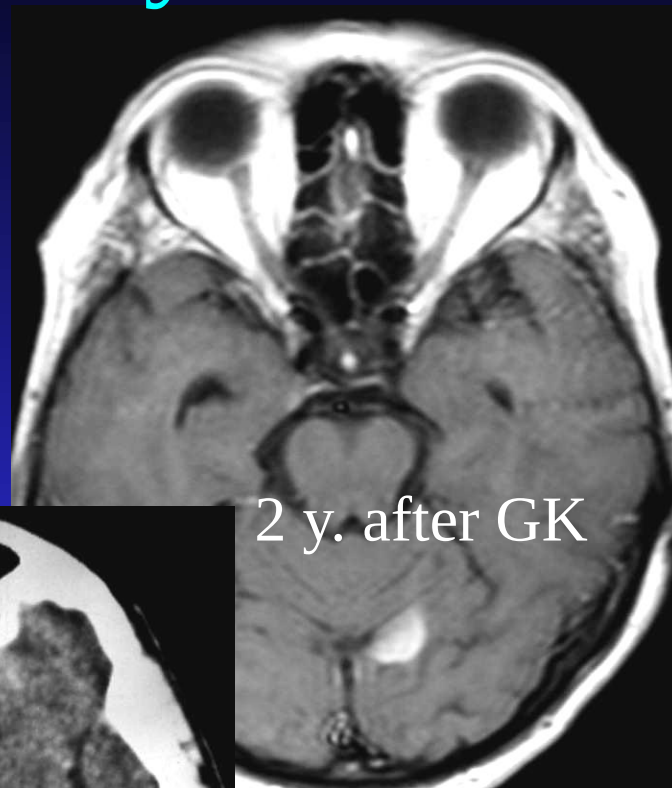
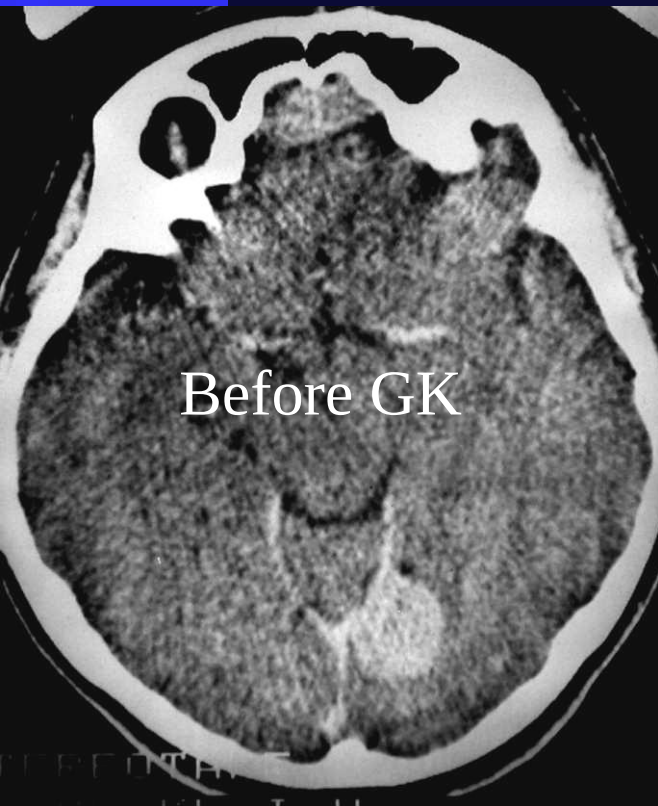
Before GK



SP
SL
Fo
2
Co



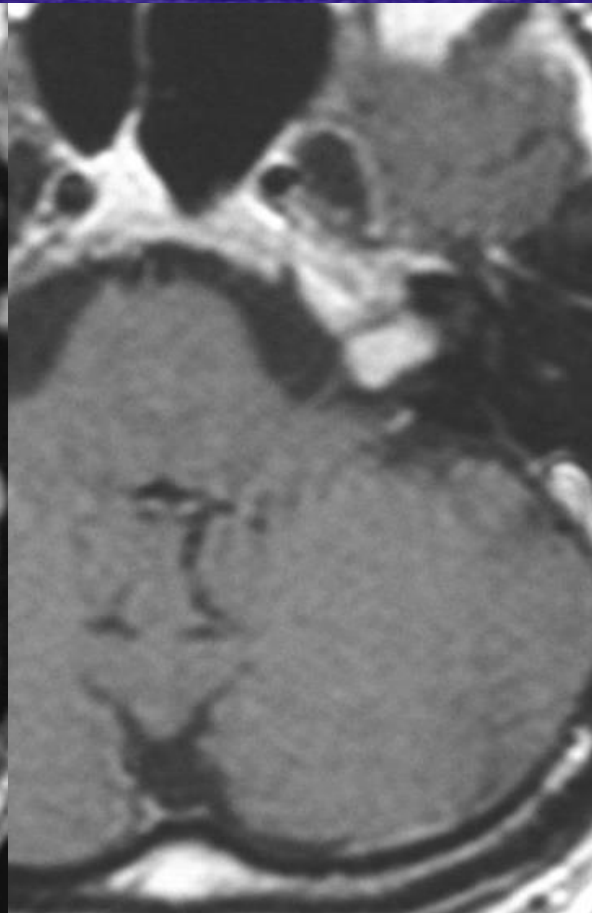
F 67 y.



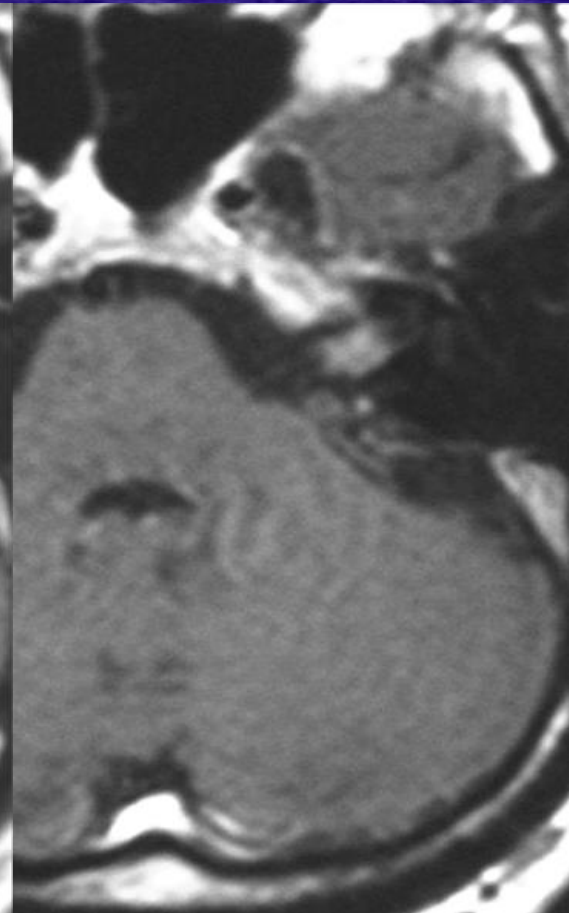
M 39 y.



Before GK



2 y. after GK

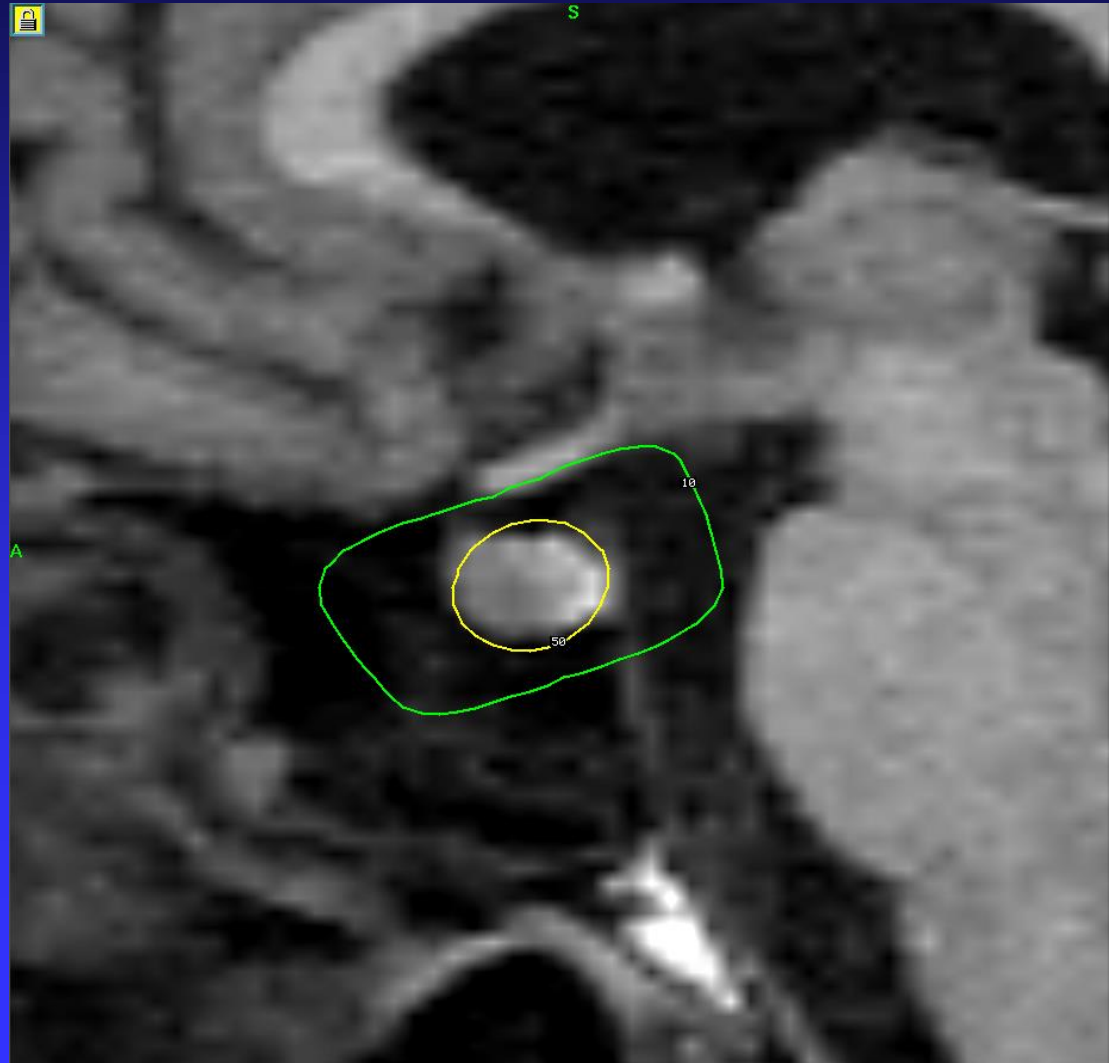


5 y. after GK

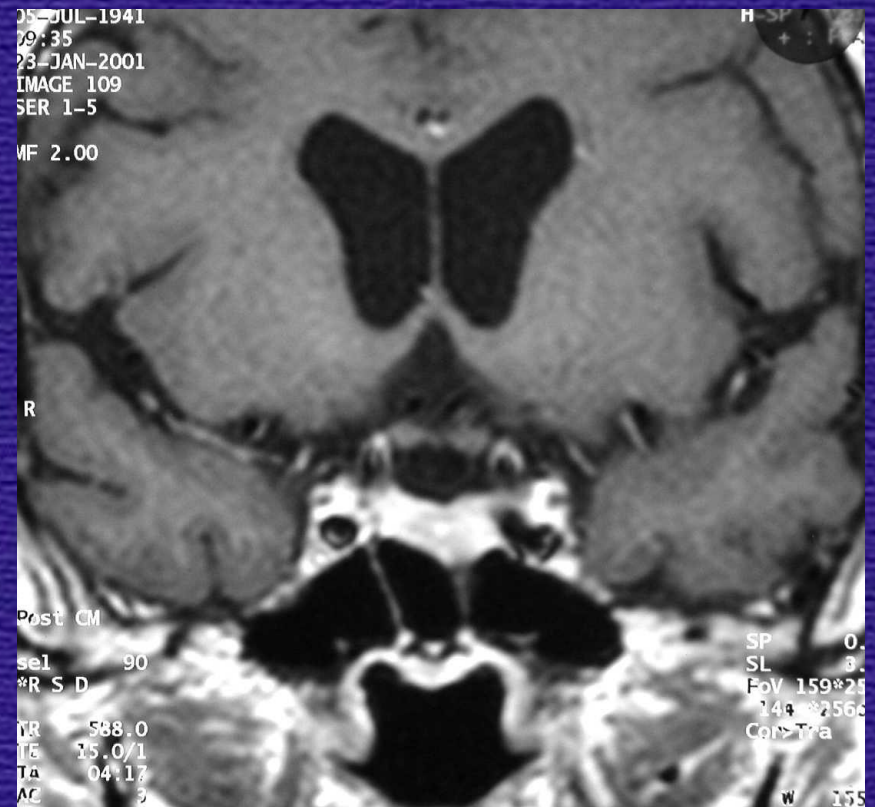
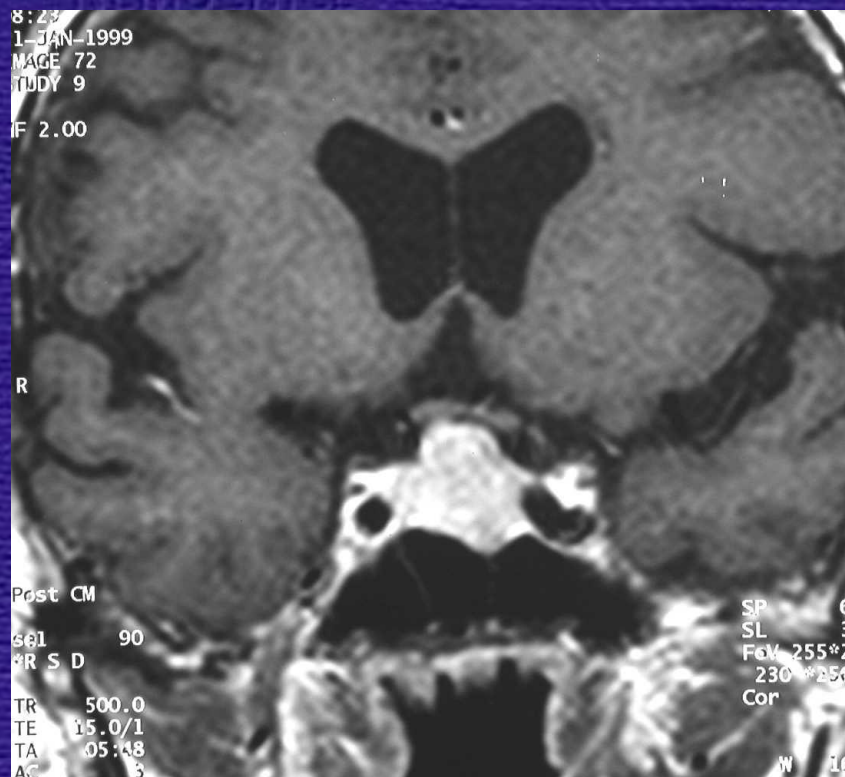
Pituitary adenomas

- | | |
|--------------------------------|-----------------|
| ■ Nonsecreting adenomas | 16-20Gy |
| ■ Acromegaly | 30-35 Gy |
| ■ Prolactinomas | 35-40Gy |
| ■ M. Cushing | 30-35 Gy |
| ■ Nelson sy. | 30-35 Gy |

Targeting of pituitary region with gamma angle 70° - 10% isodose represents 7,5 Gy and is parallel to optic pathway, 50% isodose represents 35 Gy



58 F before and 2 years after radiosurgery



M 12 y. - acromegaly



Before GKS, D min 40 Gy on 50%

– since the age of 15 stop growing, secondary hypothyreosis with substitution Euthyrox

malignant tumors

- **metastasis** 18-24 Gy
- **gliomas** 20-30 Gy
- **uveal melanoma** 36-42 Gy
- **Others** 1%

Epidemiology - incidence

lung cancer 20-65 %

breast cancer 2-25 %

renal cell carcinoma 5-10%

primary unknown 10-15 %

(lung ca, renal cell ca)

melanoma 4-20%

colorectal carcinoma 5%

others 5% (genitourinary tract, sarcoma)

lower incidence pats.aged =70 (less aggressive diagnostic approach and less aggressive disease in older pts) (the incidence rates vary depending on differences in a type of study - autoptic or clinical, patient selection and duration of follow up)

Brain metastases

increase of the incidence

- 1. possibility to detect small tumors
(magnetic resonance imaging)**
- 2. longer survival of patients with
cancer
(aggressive treatment of primary
tumors)**

Neurological functional status

1. asymptomatic
2. minor neurological symptoms
3. neurological symptoms requires medical care
4. severe neurological symptoms, intensive treatment, hospitalization
5. coma

Metastasis - 400 patients

61% solitary brain met.

39% multiple brain met. (2-4)

Complete and partial regression - 74%

No change - 19%

Progression - 7%

Late toxicity - 5%

Brain metastases

(volume, location, histology)

(recommended doses)

1. Supratentorial location

lung, breast cancer 18-20Gy

melanoma, renal cell ca 21-24 Gy

2. Infratentorial location

all histologies 18-19 Gy

The improvement of neurological symptoms

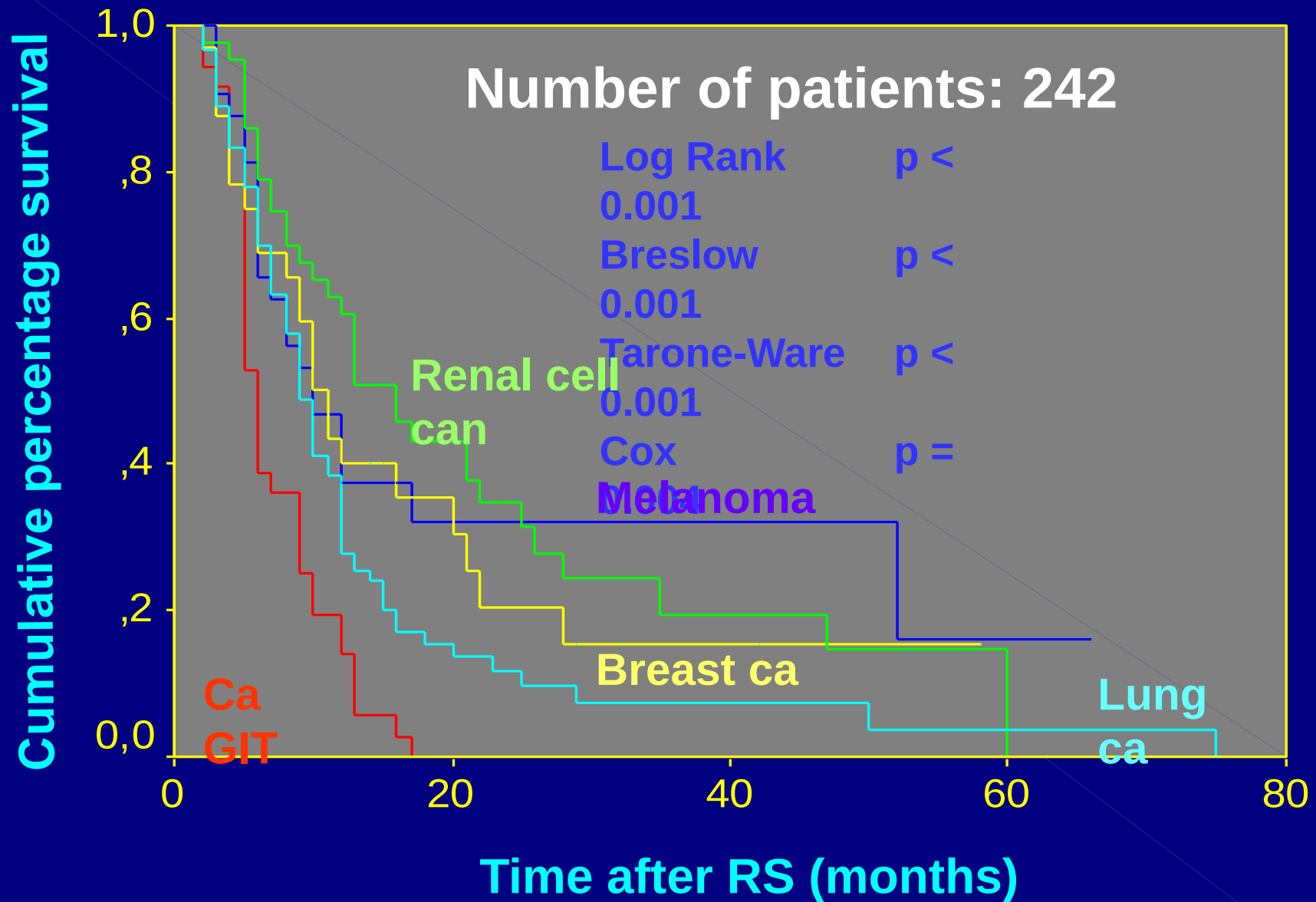
solitary lesions

- NFC -no change 73 (30.2%)
- NFC -the improvement 168 (69.4%)

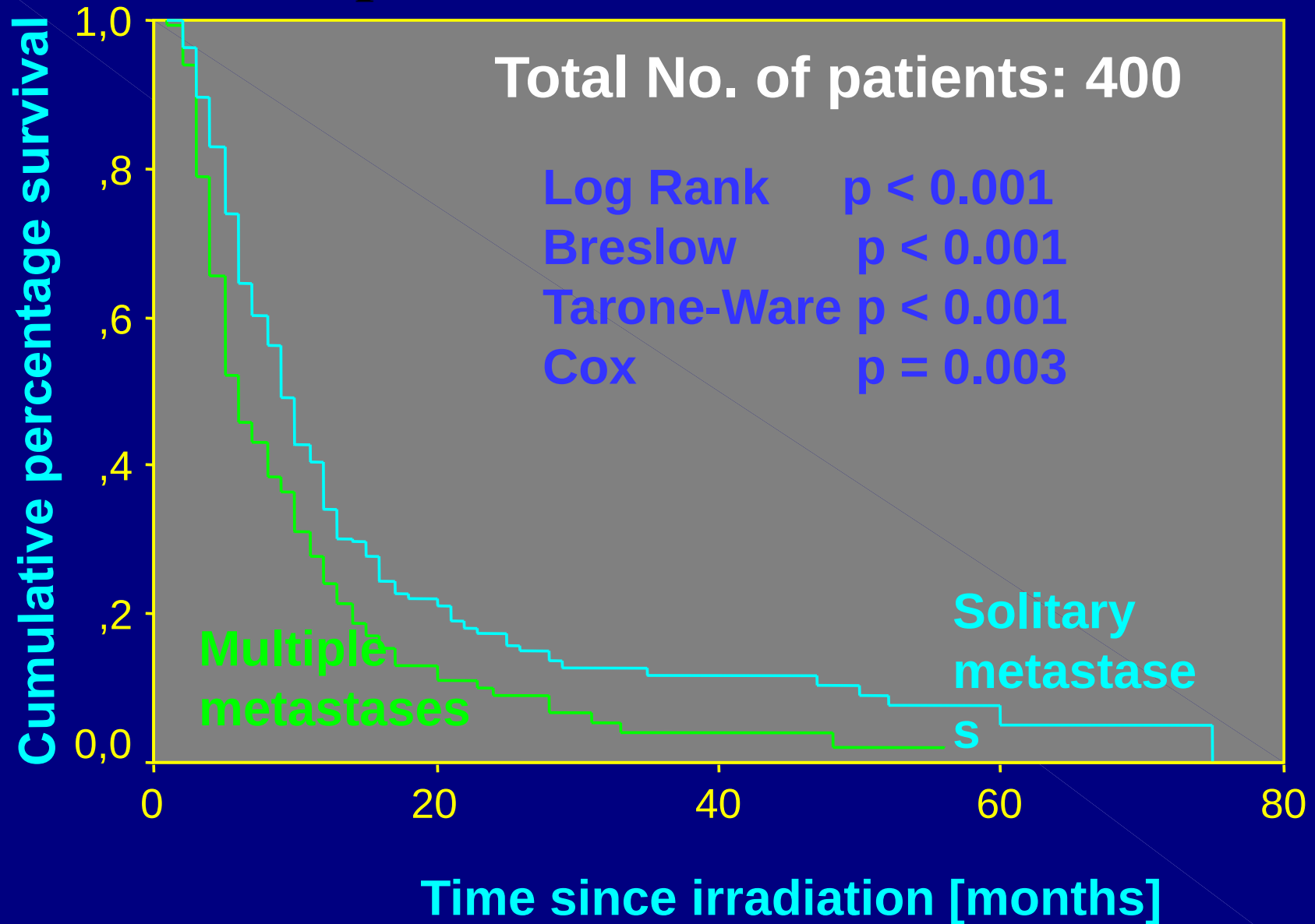
multiple lesions

- NFC -no change 70 (44.3%)
- NFC - the improvement 85 (53.8%)

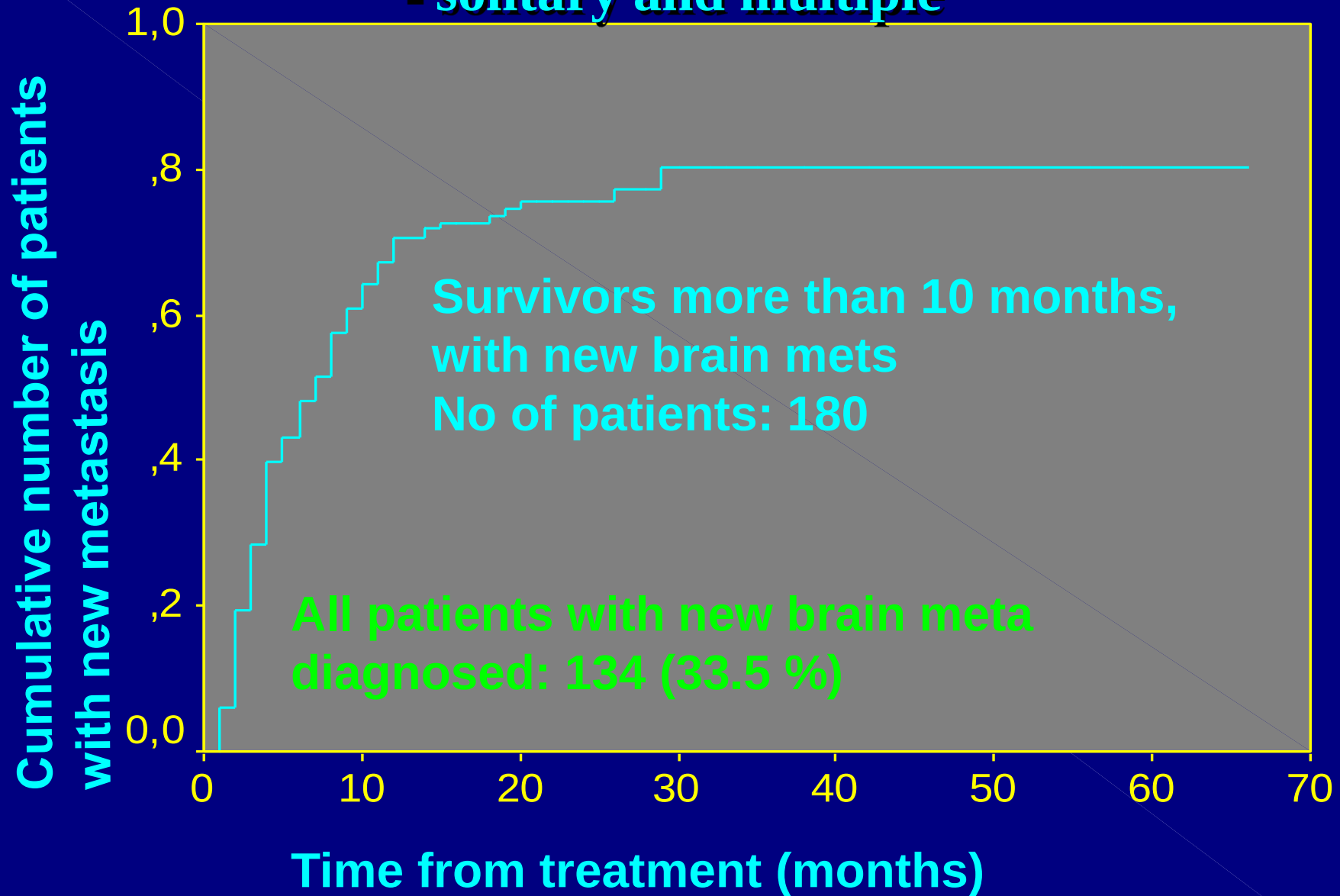
Kaplan-Meier survival curves- histology



Kaplan-Meier survival curves



Kaplan-Meier curve to new brain metastasis - solitary and multiple



Metastases – 400 patients

61% solitary brain met.

39% multiple brain met. (2-4)

Survival - median 9 months

(solitary brain met. - 10 months)

(multiple brain met. - 6 months)

Renal cancer met.- 13 months



Prognostic factors for survival solitary brain metastases

age

severity of neurological symptoms

other organ dissemination

status of primary tumor

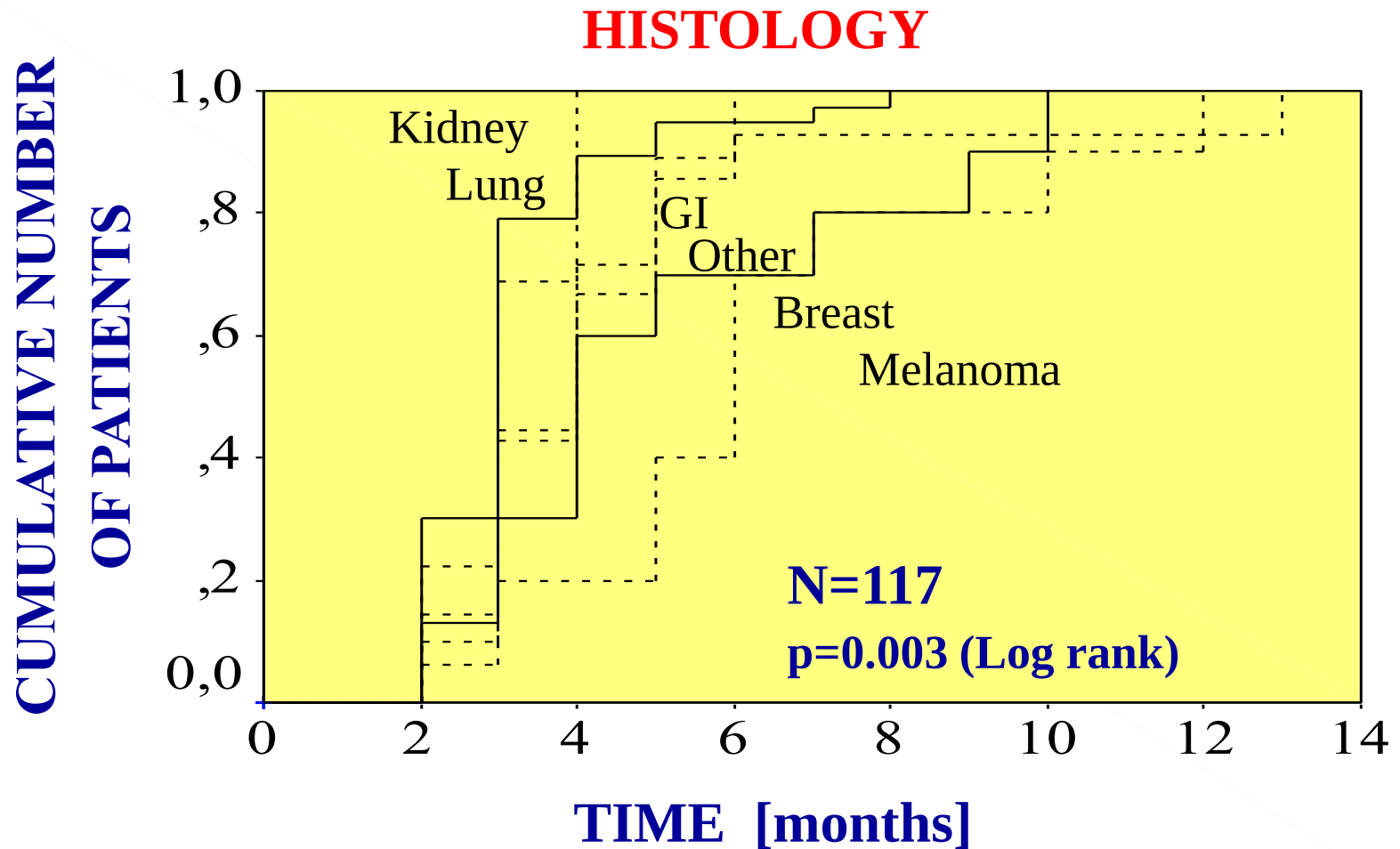
the interval between Dg of BM and Dg of primary tumor

histology

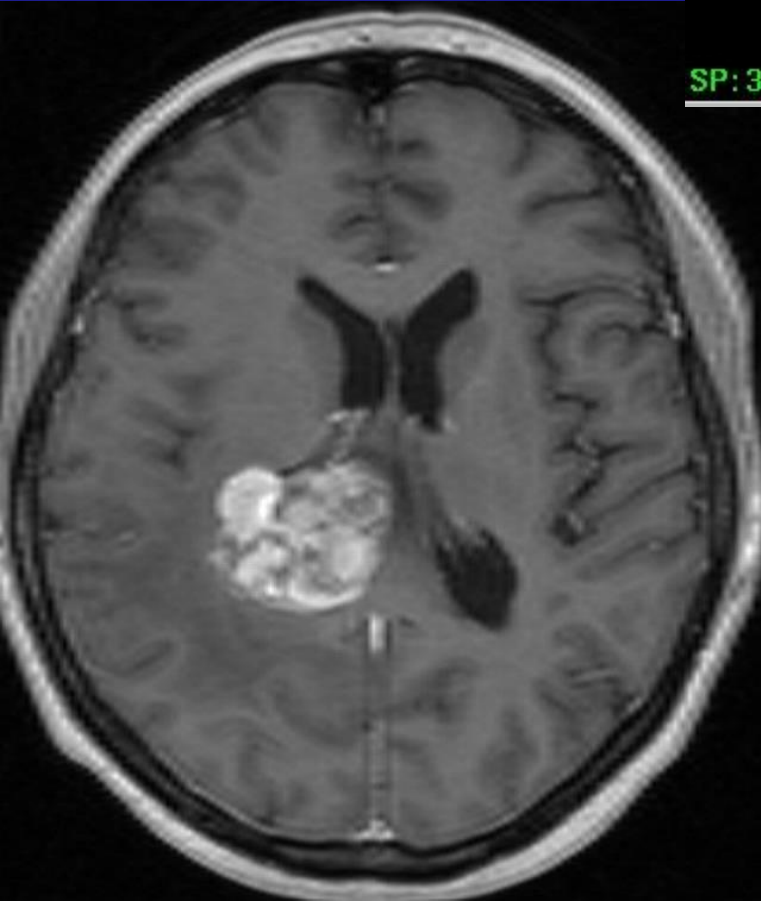
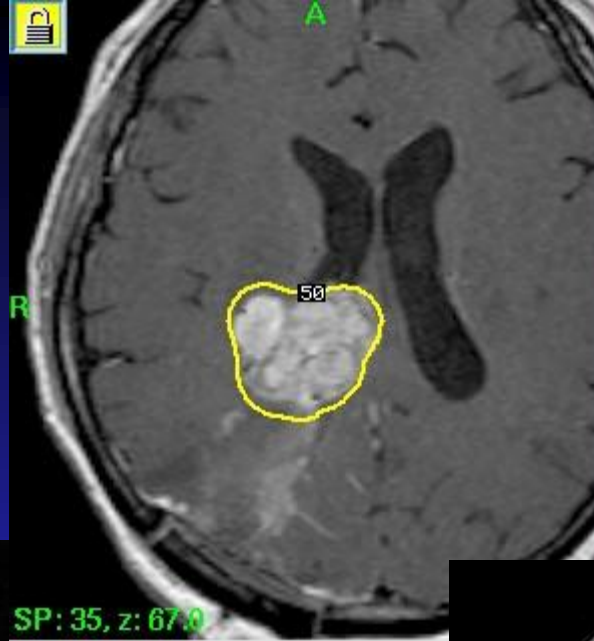
minimum applied dose

KAPLAN –MEIER CURVE

TUMOR RESPONSE

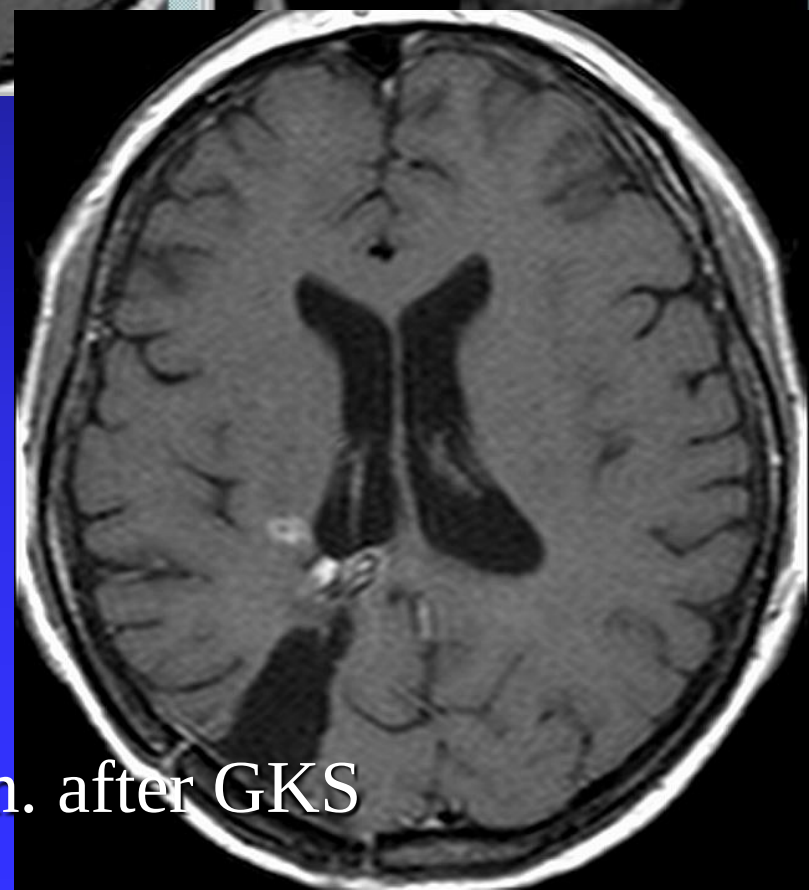


F 58 y. - kidney
cancer



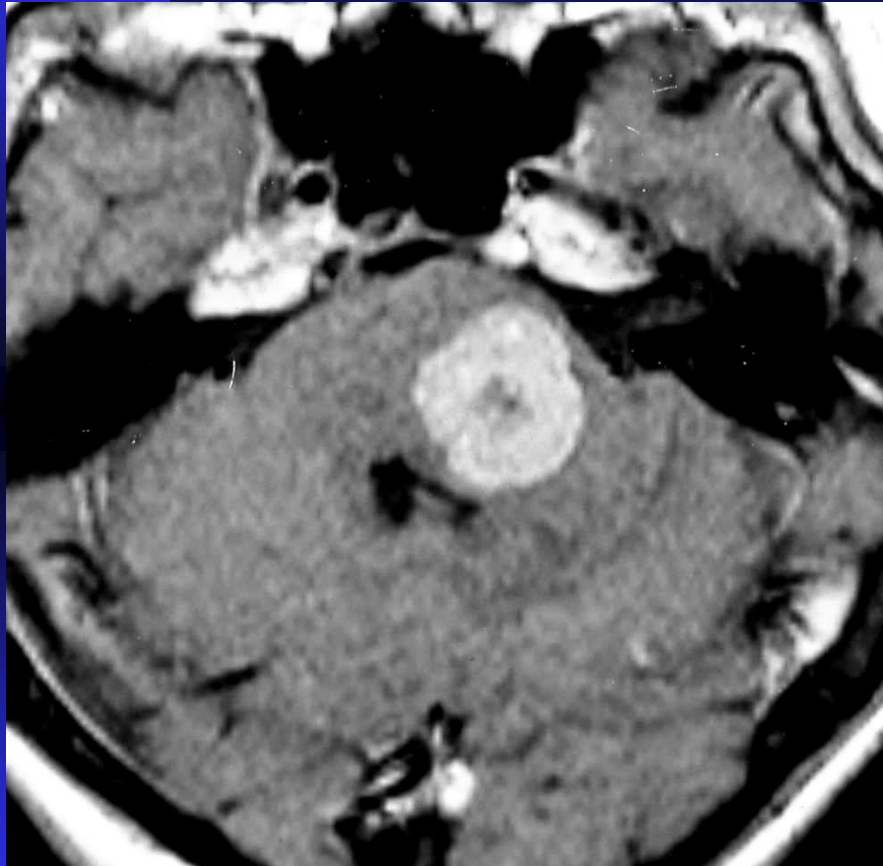
SP: 35, z: 67.0

16,3 cm³,
17 Gy 50%

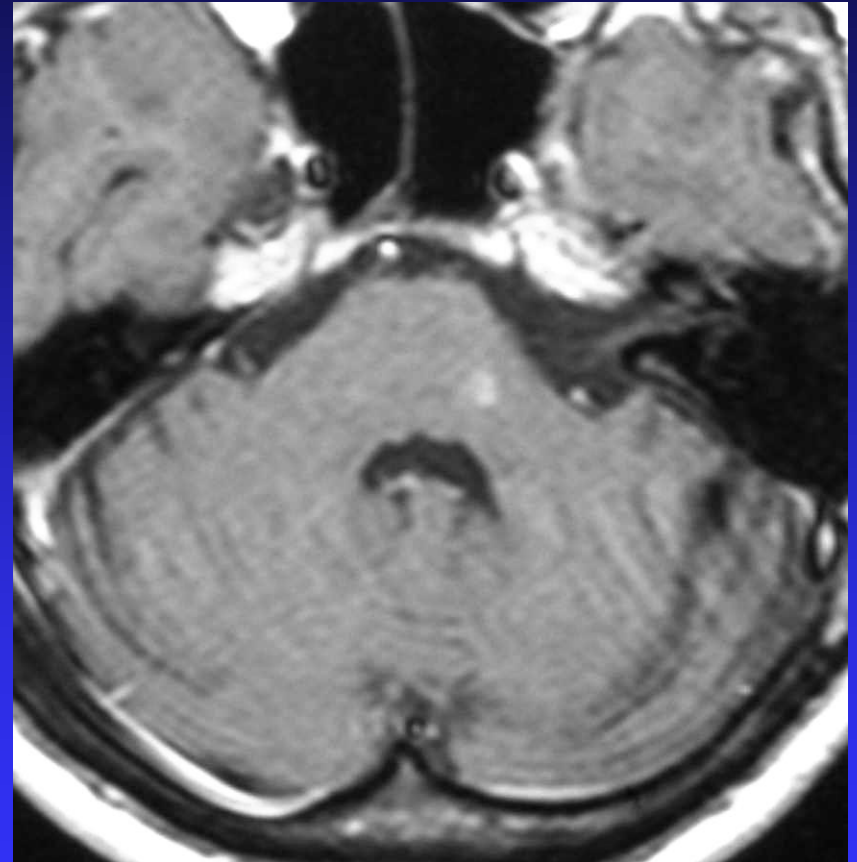


21 m. after GKS

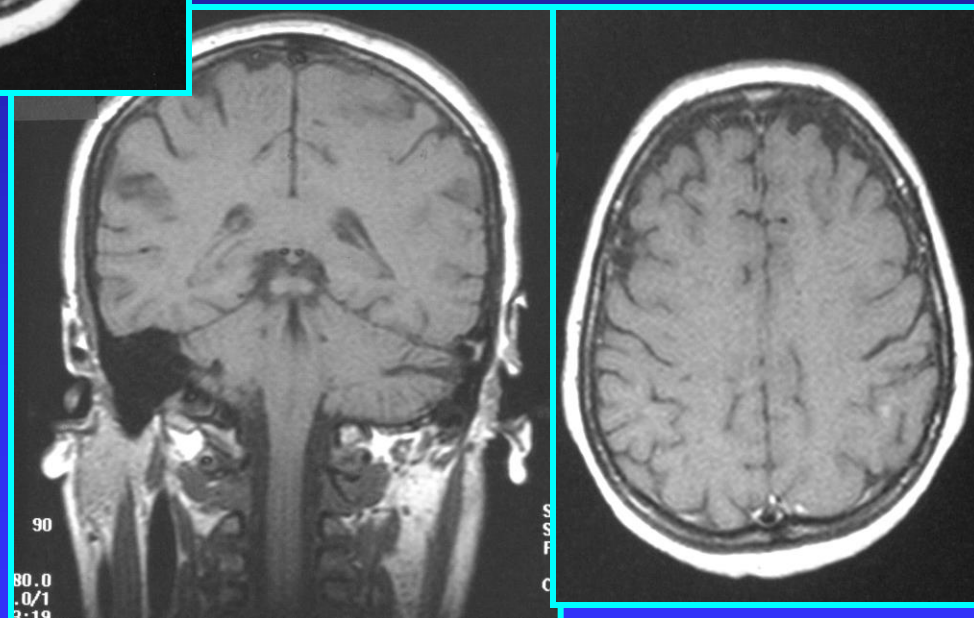
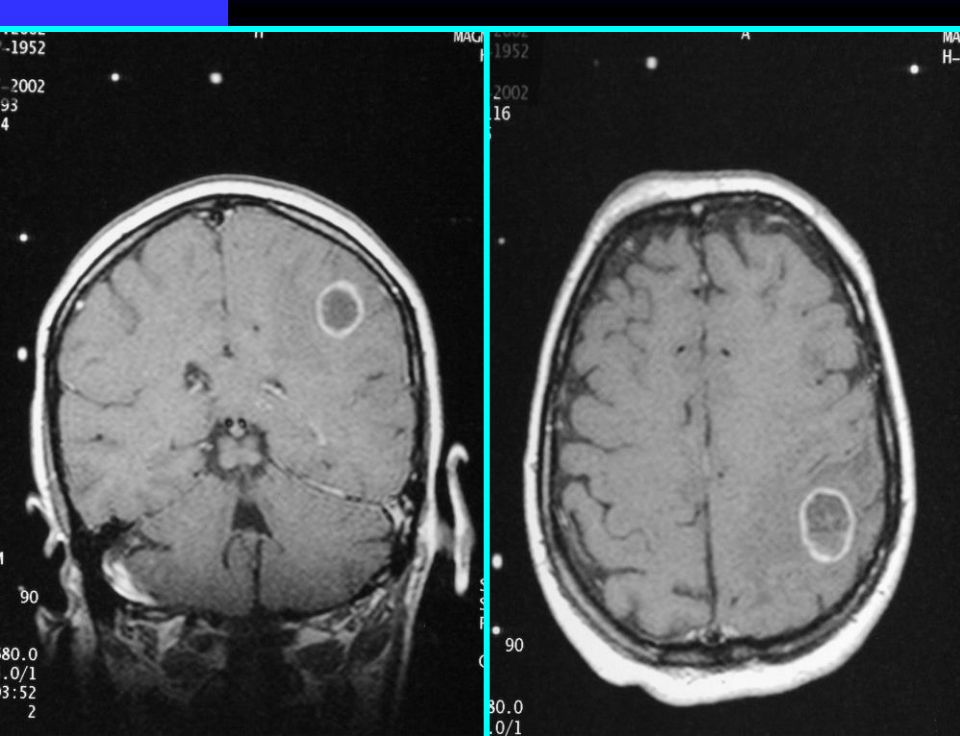
F 44 y. (breast cancer)



Before GK

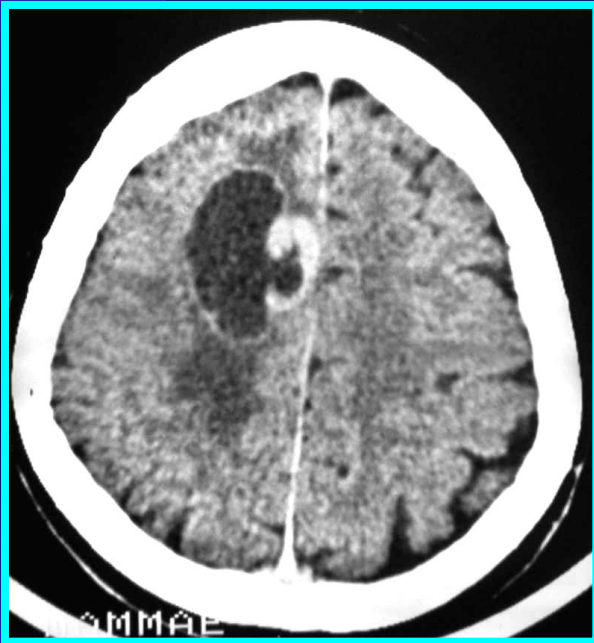


PFS 12 years

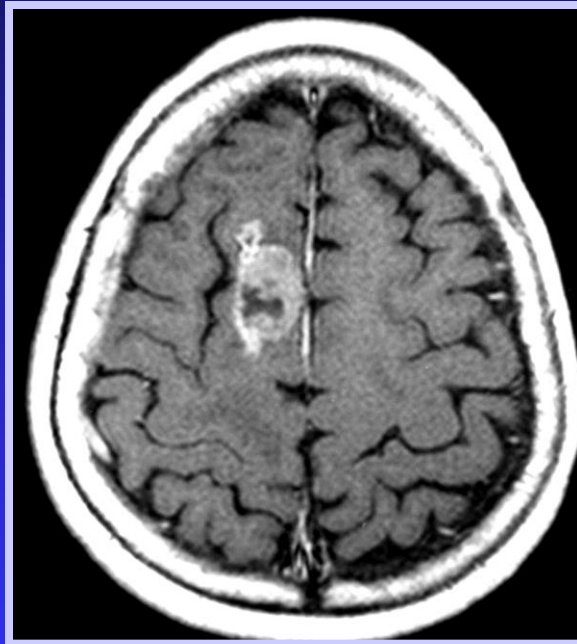


Solitary brain meta of melanoma
PFS 48 months

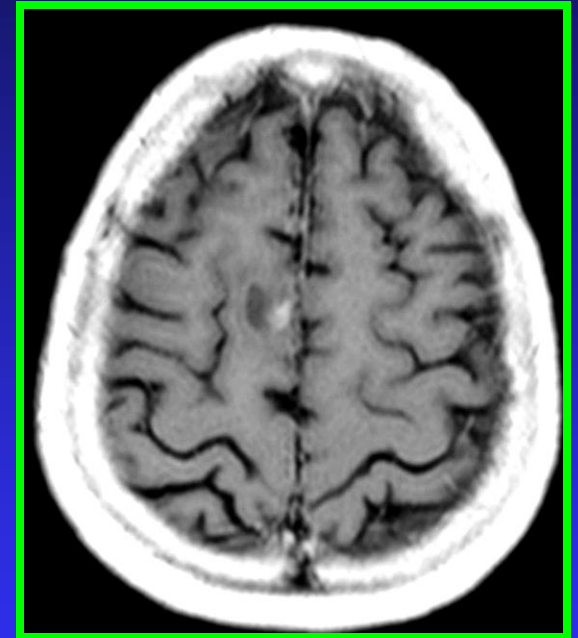
F 62 y. - breast cancer



Before stereotactic
evacuation of the cyst

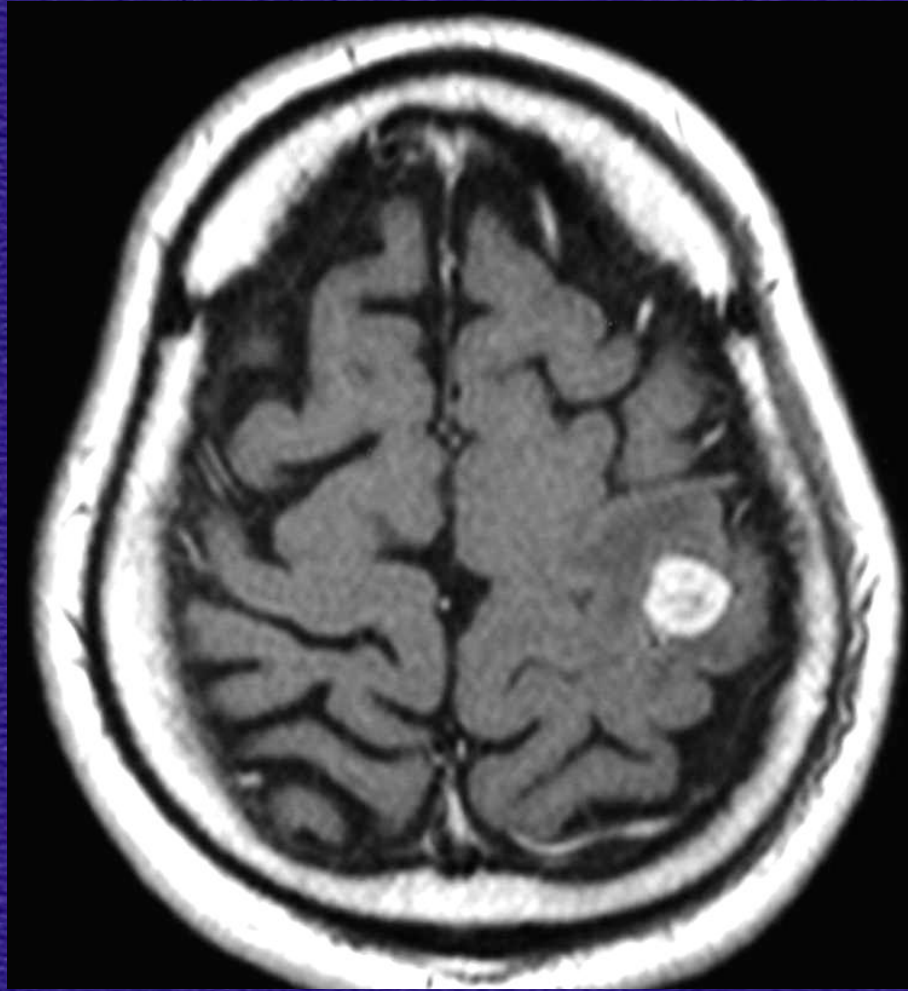


Before GK

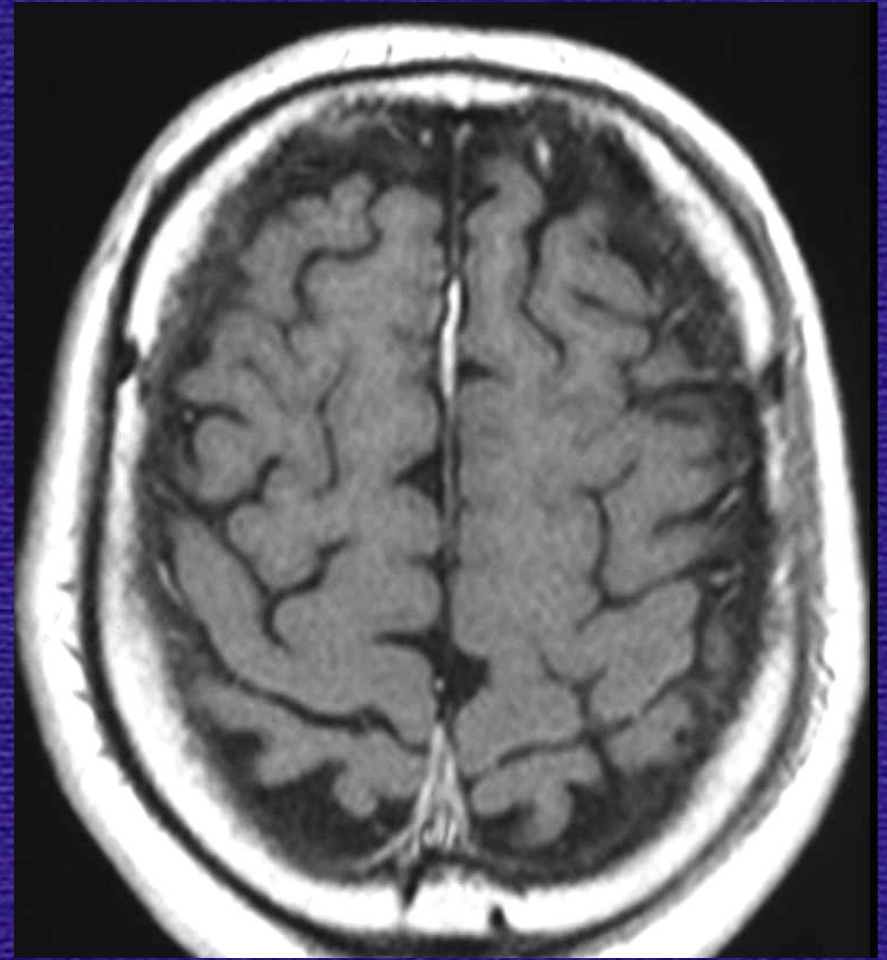


5 m. after GK

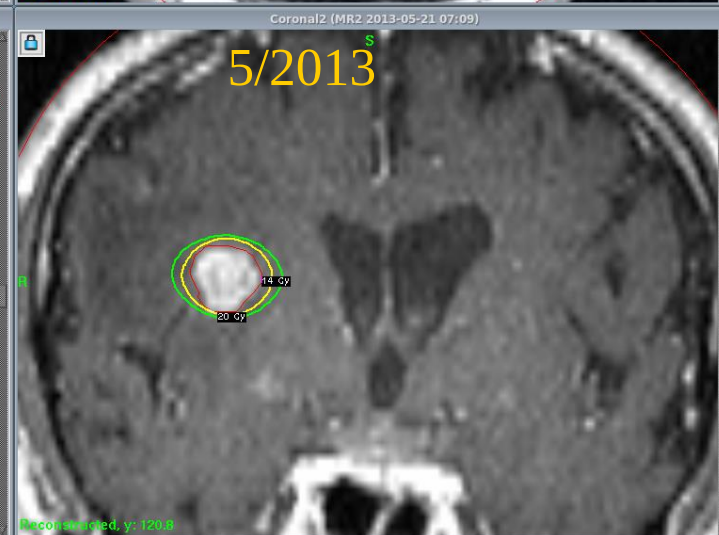
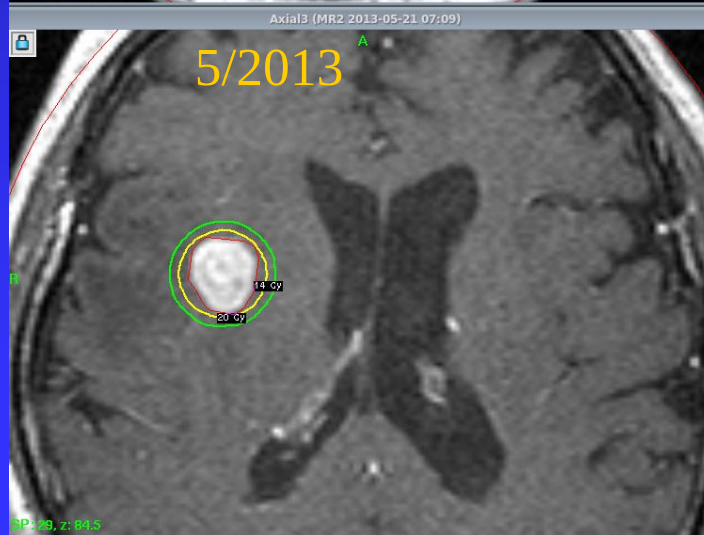
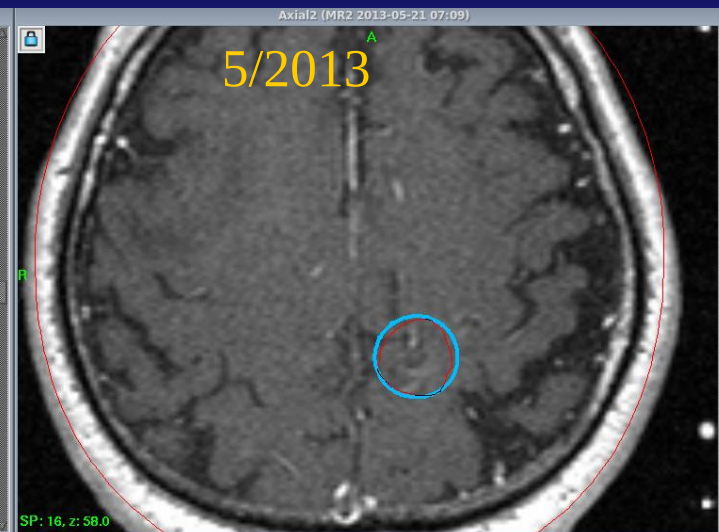
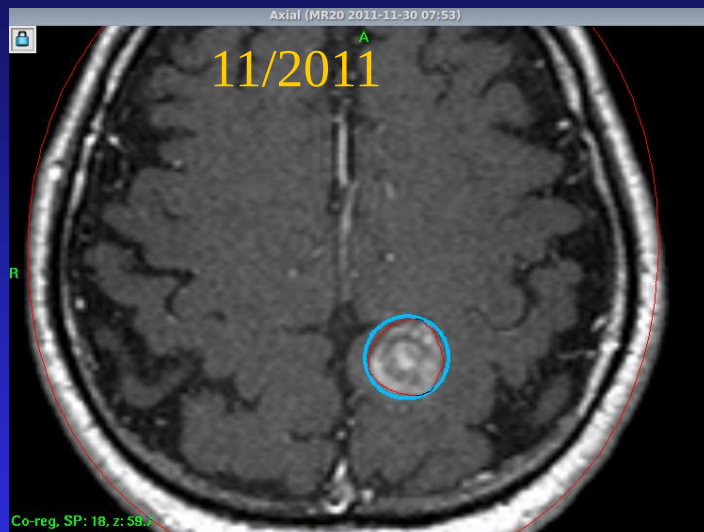
M 51 y. - kidney cancer



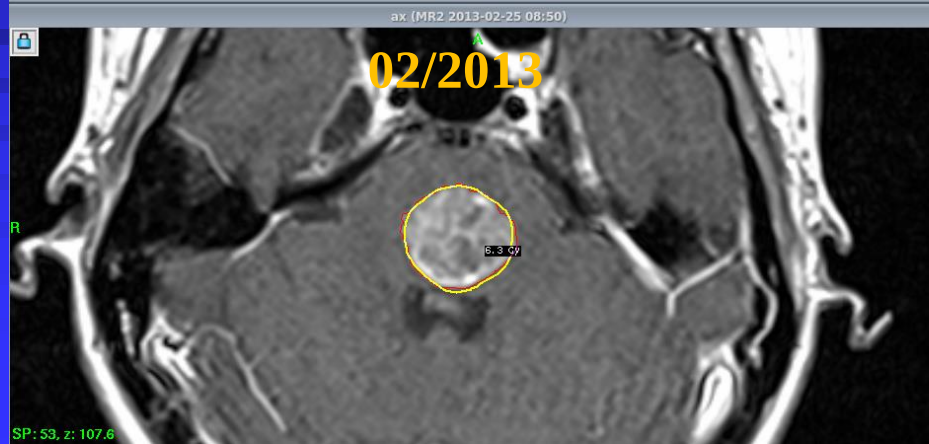
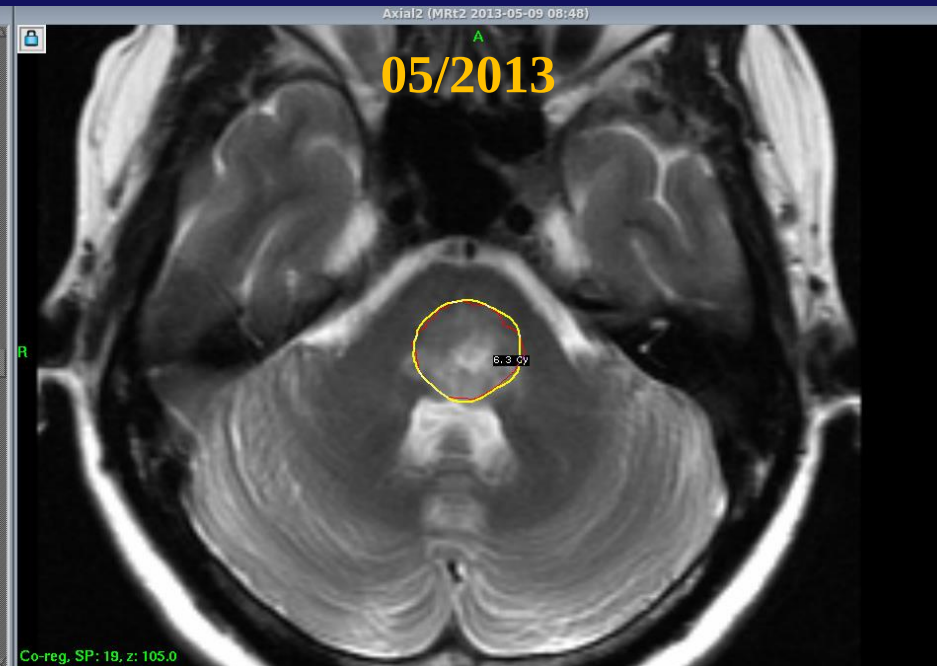
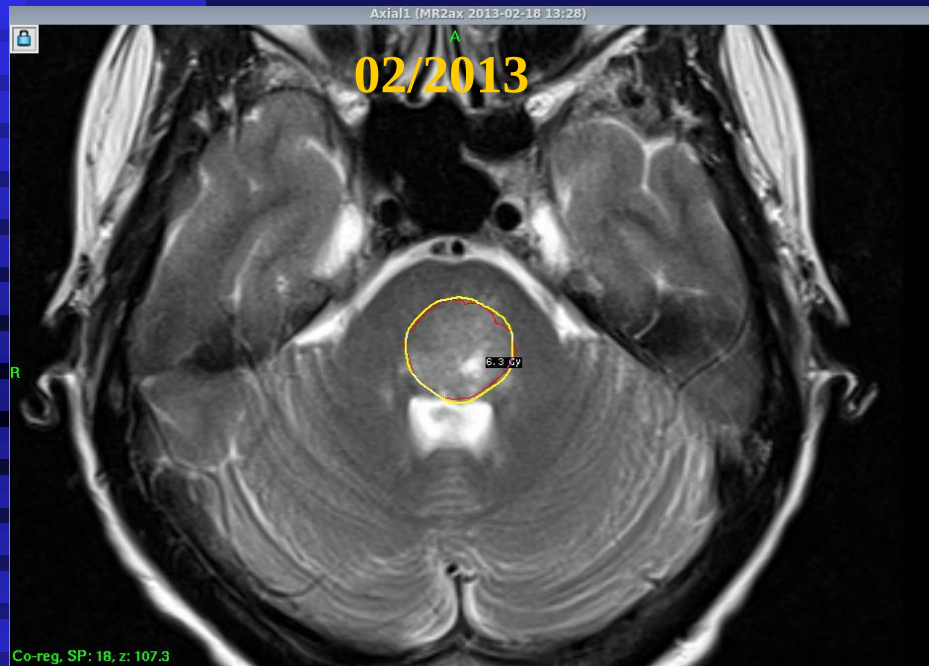
Before GK

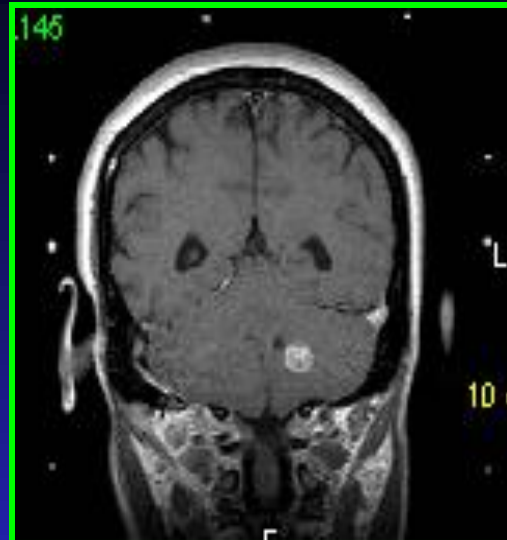
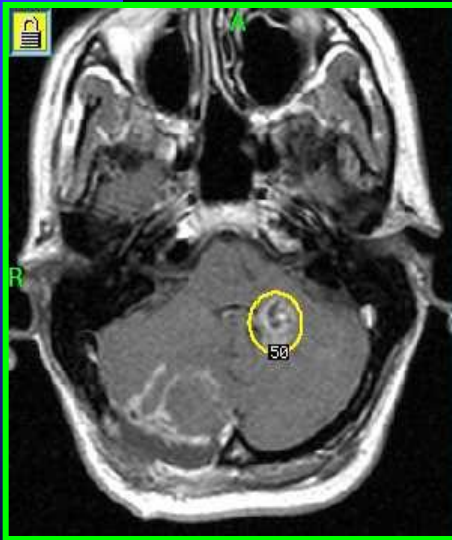


1 y. after GK

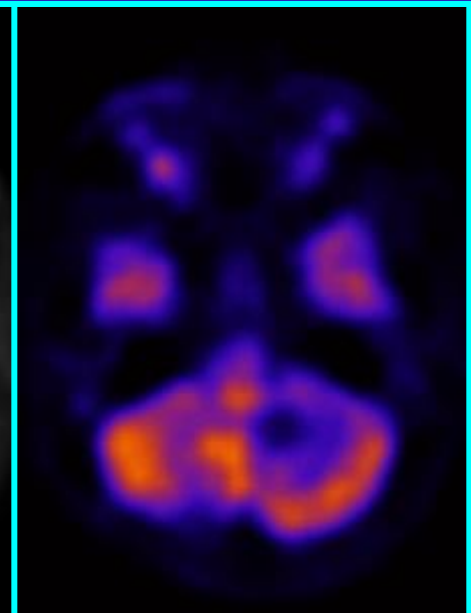
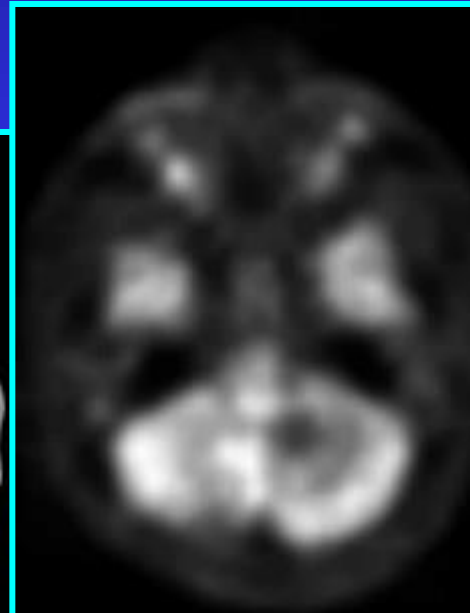
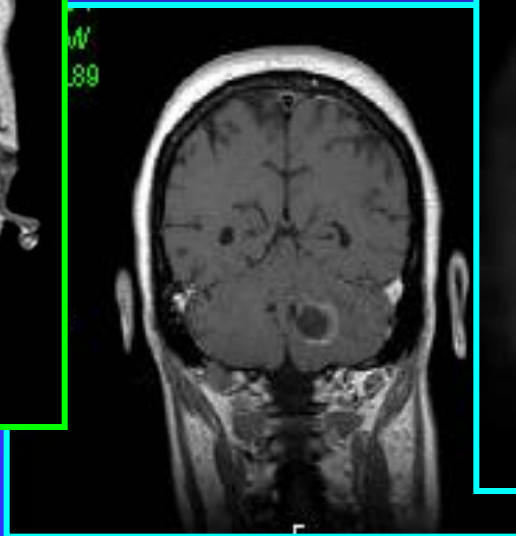
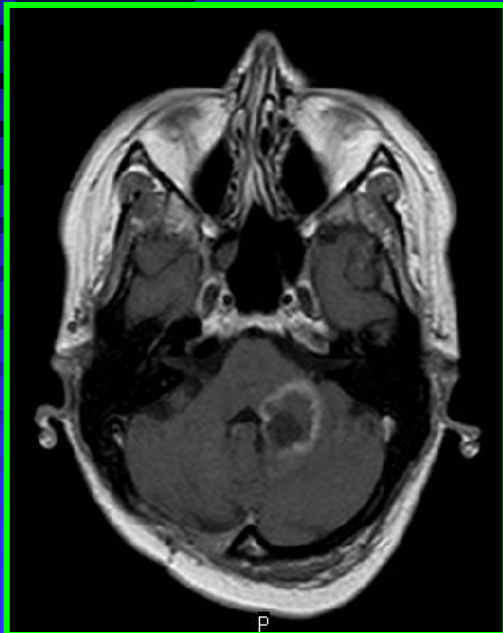


19 Gy na 50% isodózu ve 3 frakcích, PIV 5660 mm³





Radiation related toxicity
12 months after RS



Long term survival(brain metastases)

9% of pts.

Min.PFS 60 months

median of age 53 years

median of KF 90%

median of time to BM 19 months

median of PTV 3 300 cmm

median of D min 21 Gy

median of mean diameter 18 mm

median of PFS 90(60-142) months

primary unknown, breast ca, melanoma

Brain metastases (RS,WBRT) -

quality of patients life

local tumor response

complications rate

(cumulative neurotoxicity from recurrent BM and their treatments)

(parietal lobe-improvement in executive functions, decline learning and memory)

prospective studies

1. Chang E.L.et al. Prospective neuro-cognitive evaluation of patients with 1 to 3 newly diagnosed brain metastases treated with stereotactic radiosurgery alone.Int J Radiat Oncol Biol Phys 2004,60(1): 164-165
- 2.Chow E.L. et al. Prospective assessment of quality of life following whole brain radiotherapy for brain metastases.Int J Radiat Oncol Biol Phys 2004,60(1):252-252

Low grade glioma I.

45 pts.

median of age 16 (3-62)

median of PTV(planning target volume) 3 300 mm³

Median of Dmin(minimum dose) 25 Gy

Low grade glioma II.

43 pts.

median of age 27 (3-54)

median of PTV 4 000 mm³

median of D min 25 Gy

LGG

71 patients (pts) SFRT-5 fractions

2 pts. SFRT –10 fractions

1 pts. SFRT- 2 fractions

14 pts. RS –single fraction

median of BED 93,6 Gy

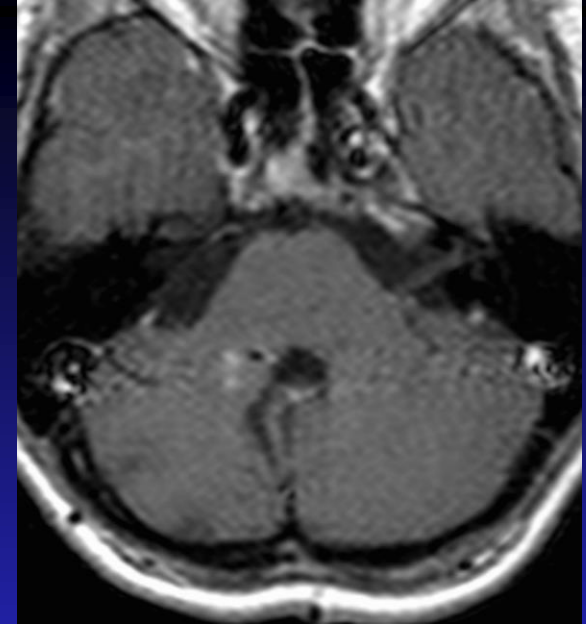
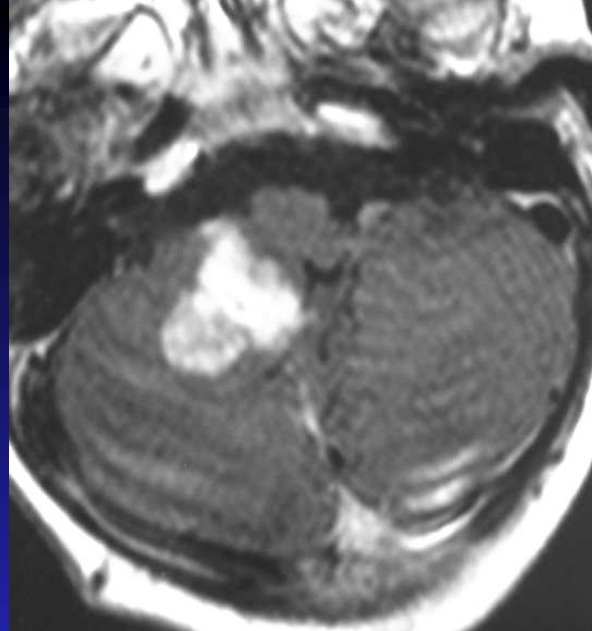
BED (Biologically Effective Dose)

$$BED = n * d * \left(1 + \frac{d}{\alpha / \beta} \right)$$

n ... number of fractions

d ... dose per fraction [Gy]

α/β ... ratio – late versus early effects, tissue specific [Gy]



F 3 y. before
neurosurgery

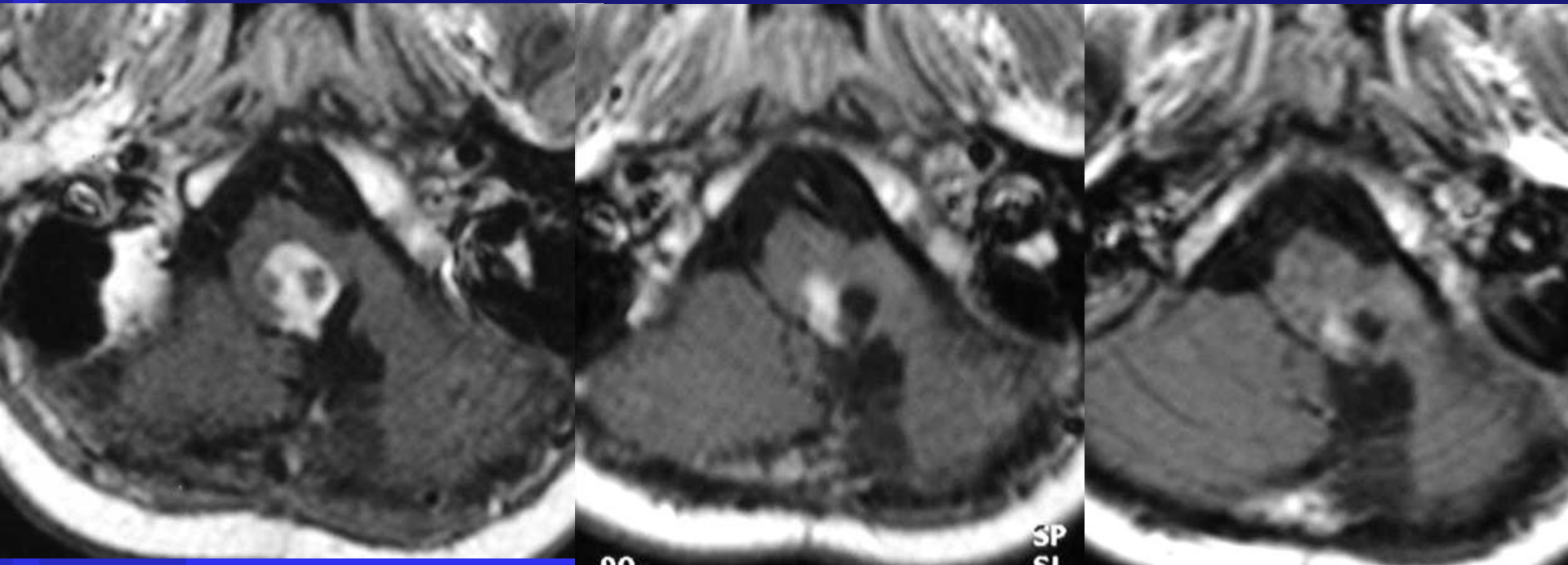
Before SFRT

8 years after SFRT

SFRT – 52,5 Gy max., 21,25 Gy at 50%, 5 fractions – in 5 days

PFS – 13years, no late toxicity, no neurodeficit, normal psychomotoric development

F 12 y. - AII (mikrosur., FRT)

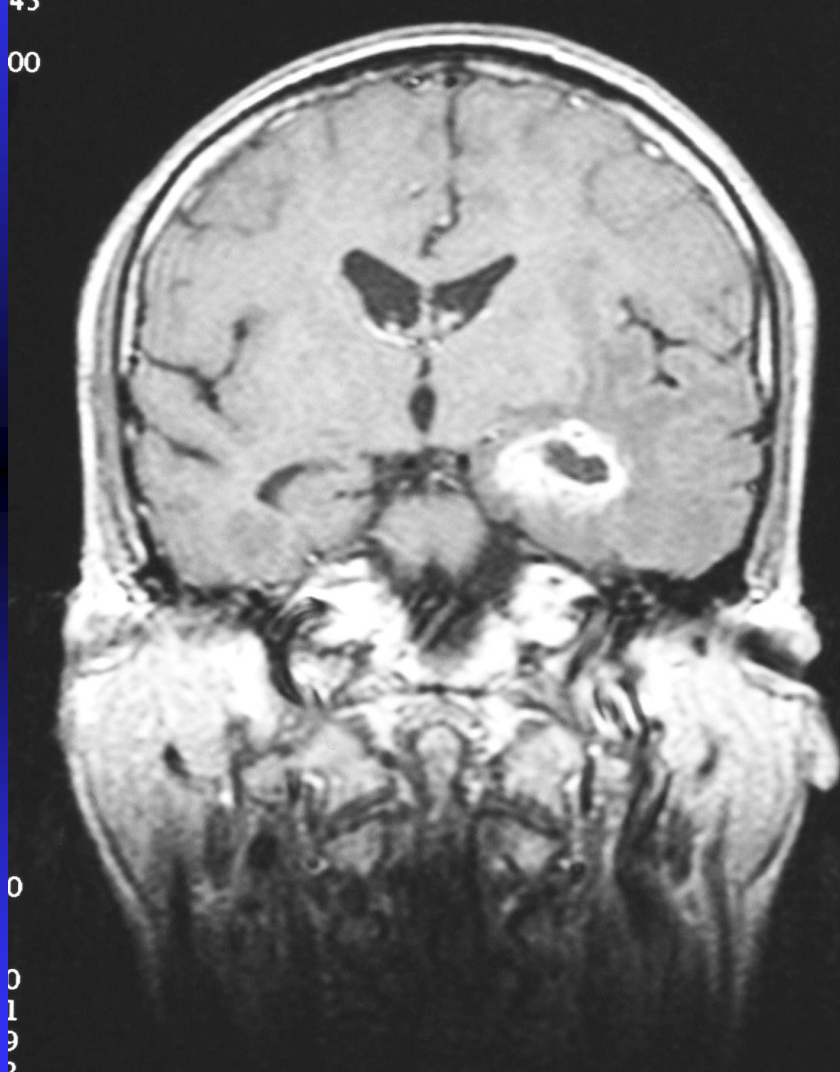


Before GK

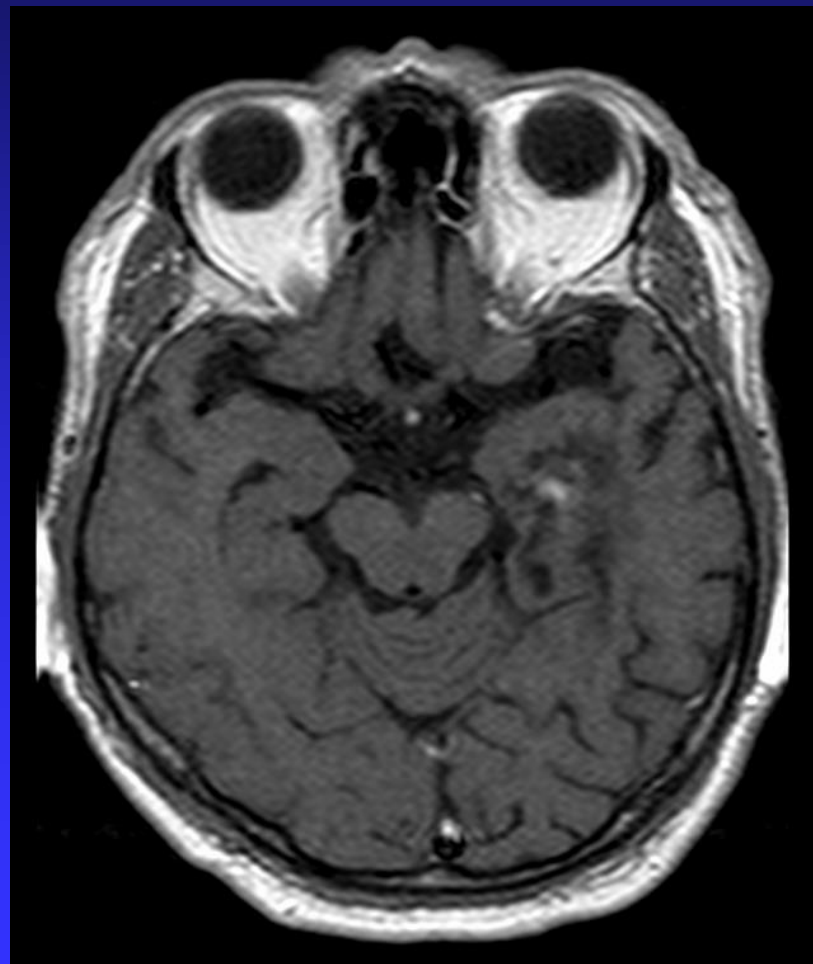
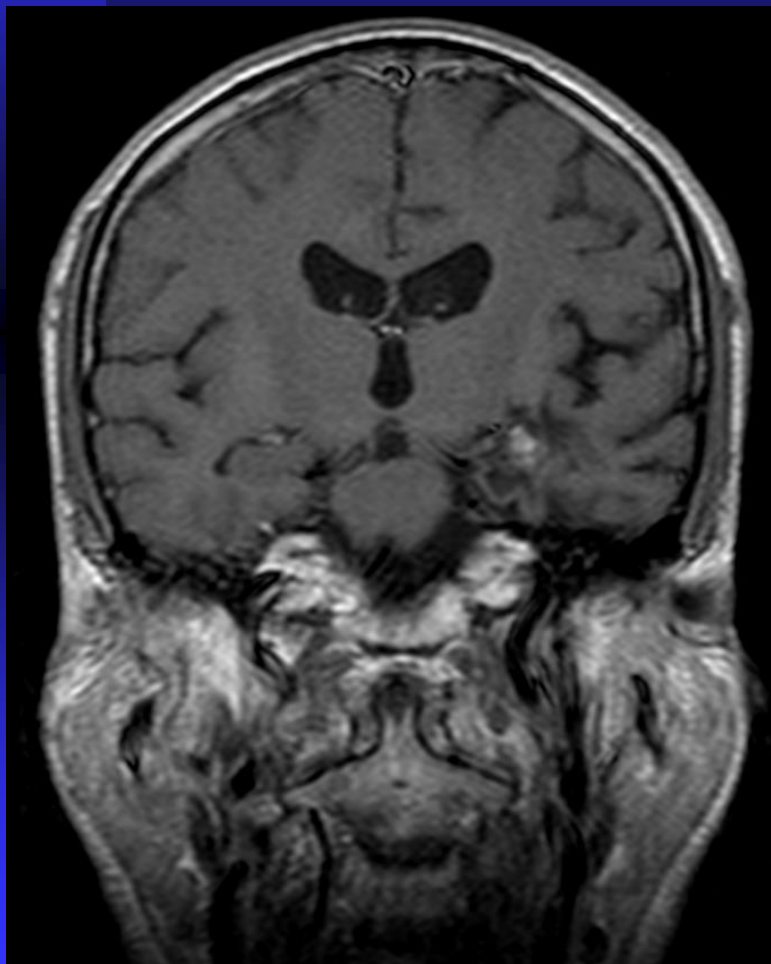
1,5 y.

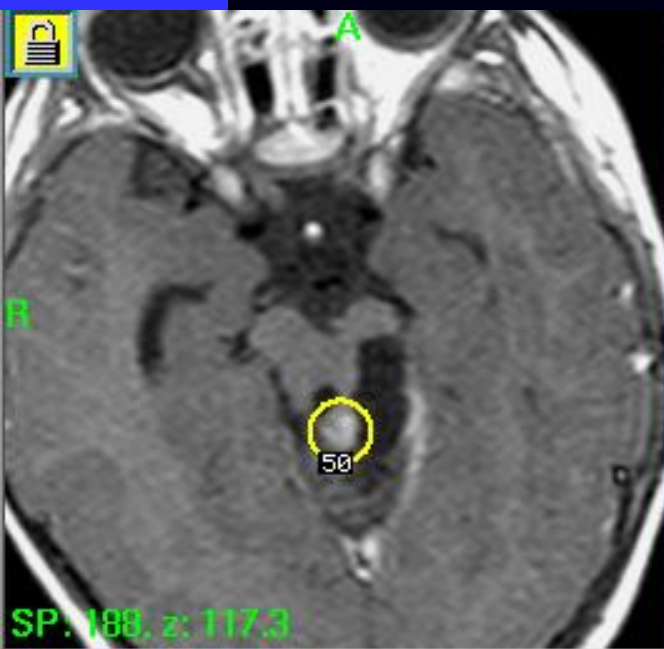
4,5 y.

Low grade glioma (residual lesion diameter 15 mm, 12 months after LGK)



Late post irradiation response low grade glioma 4 years after LGK



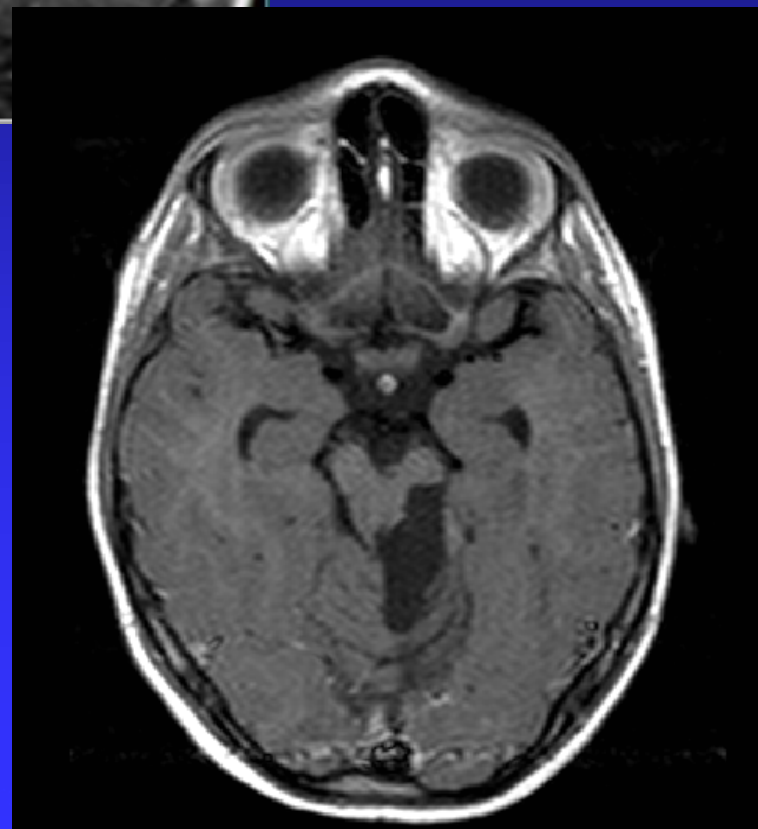


Low grade glioma I.

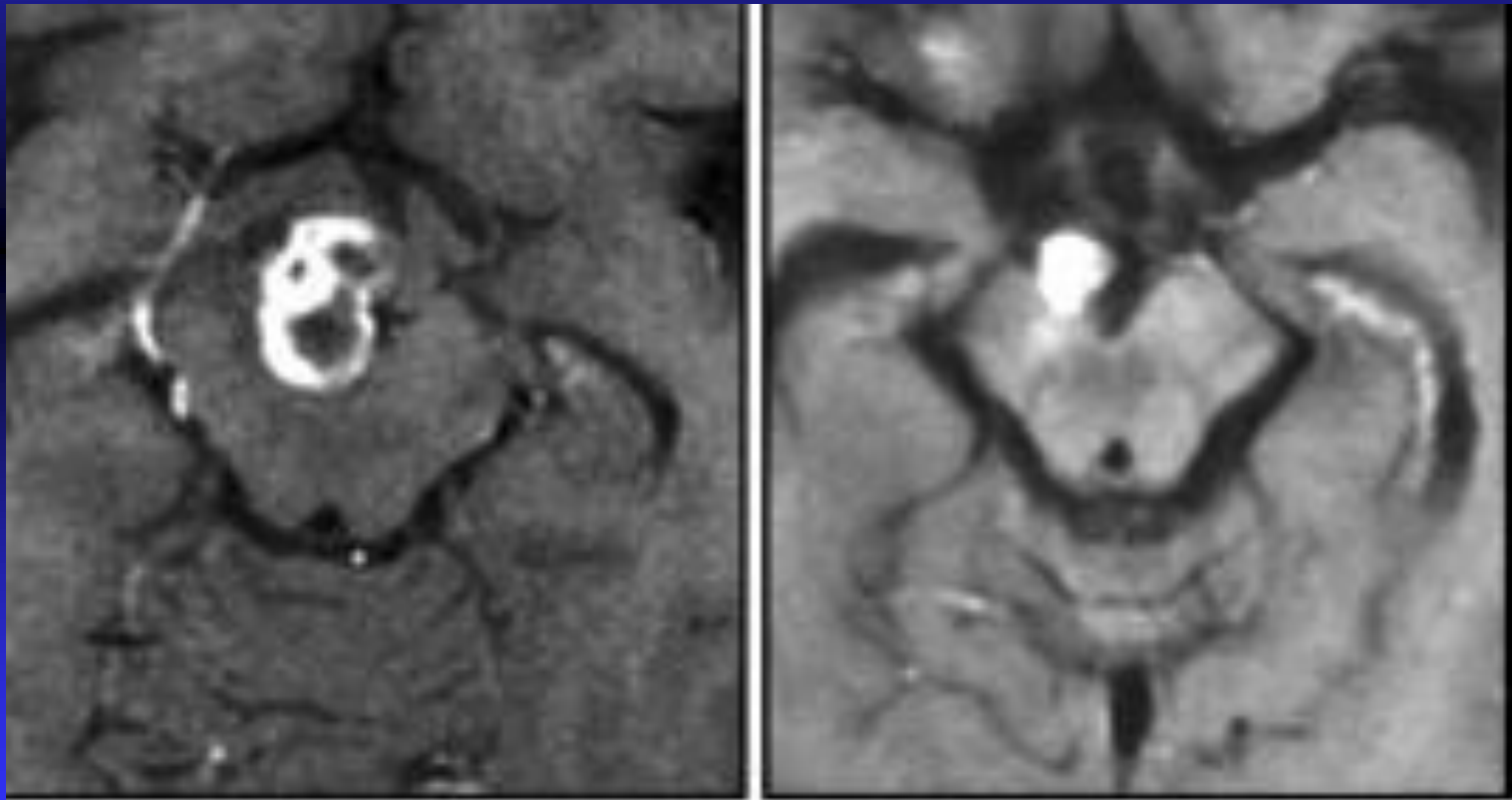
PTV 454 cmm, D min 19 Gy

PFS 82 months,

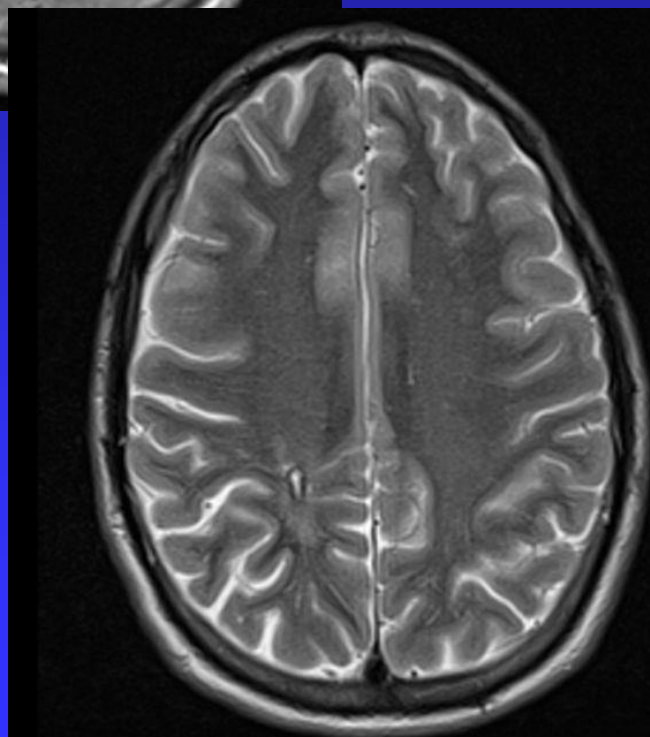
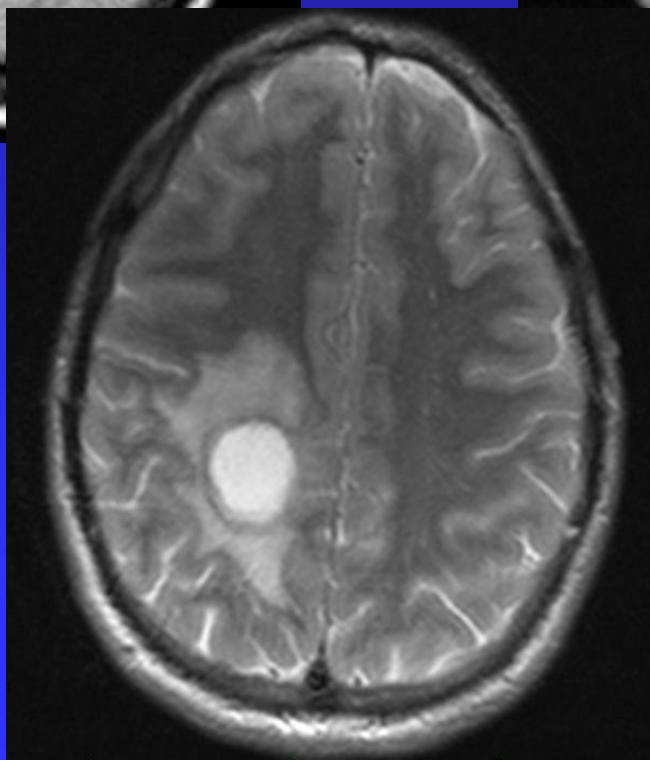
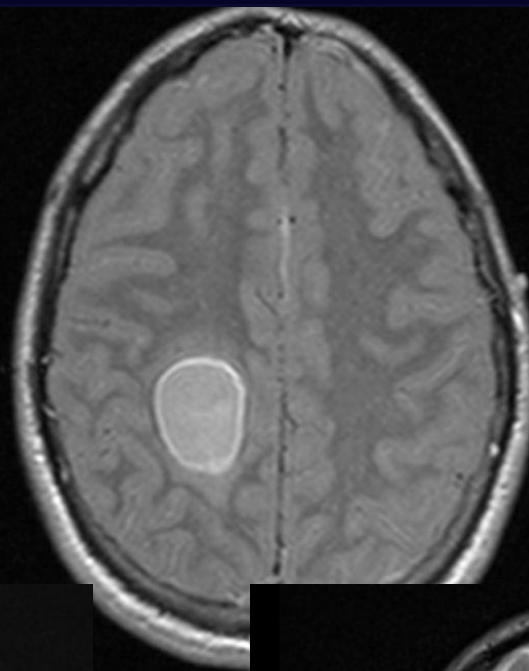
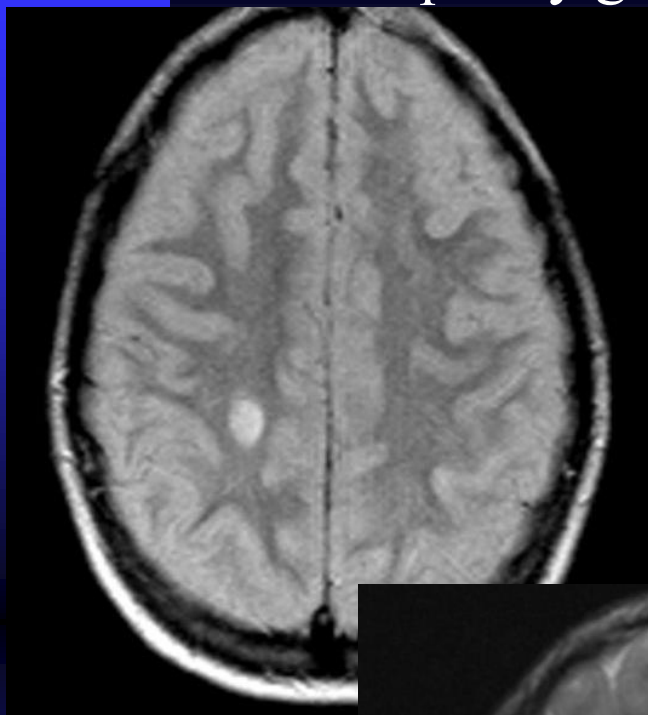
late toxicity: O



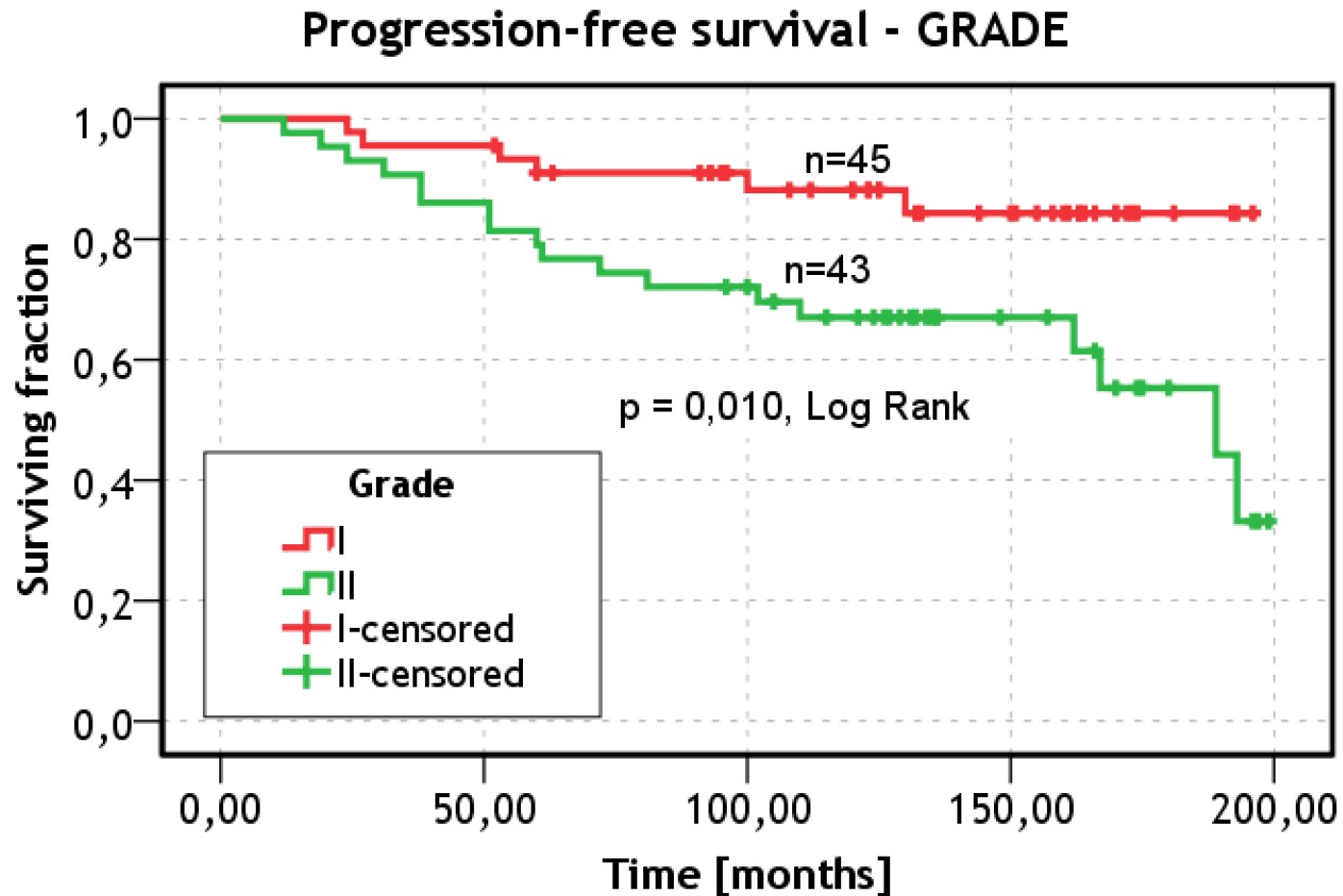
LLG before and 3 years after LGK



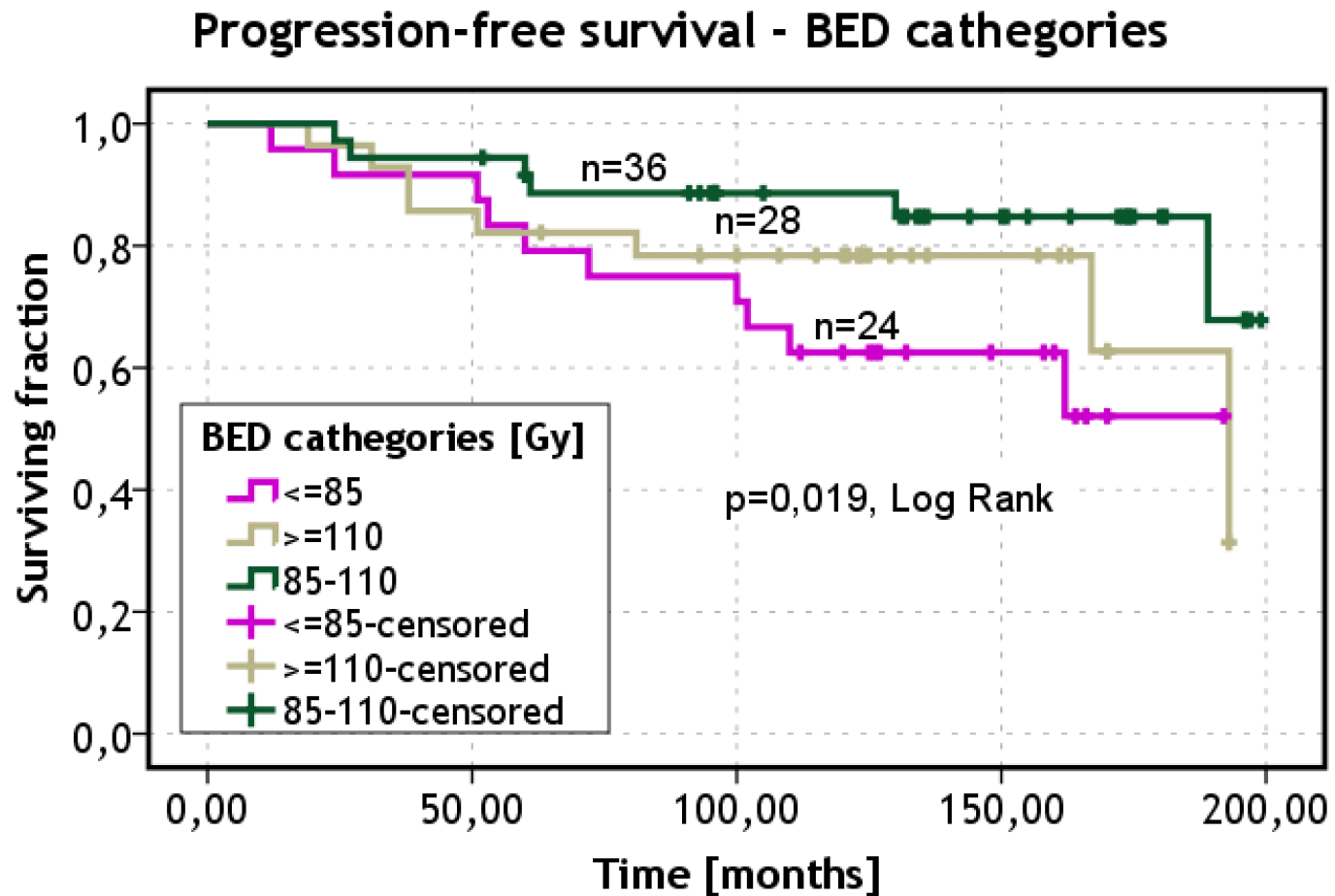
nízko-stupňový gliom aplikace Ytria 90



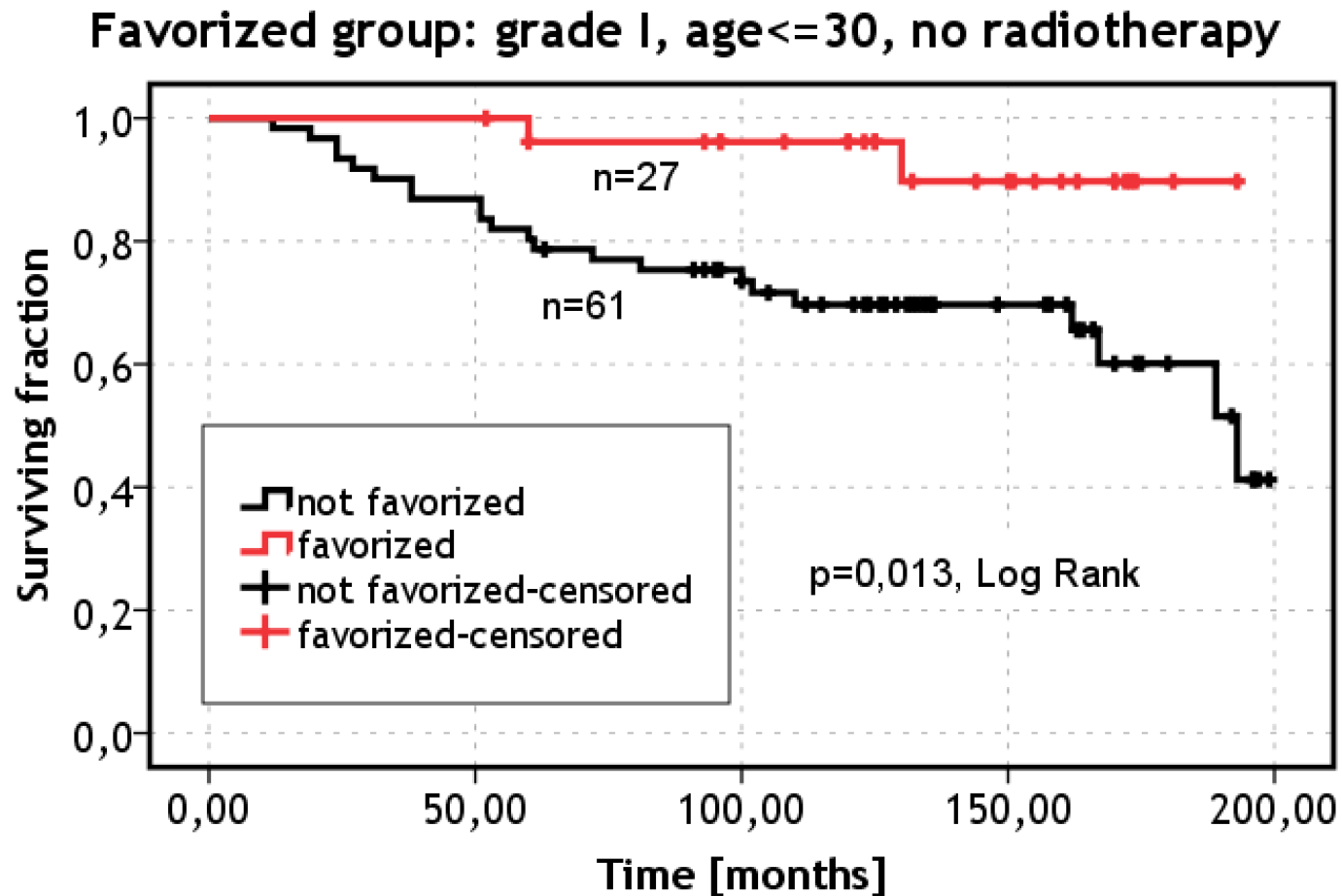
Low grade glioma -results



Low grade glioma -results



Low grade glioma -results



Low grade glioma -results

PFS (progression free survival)

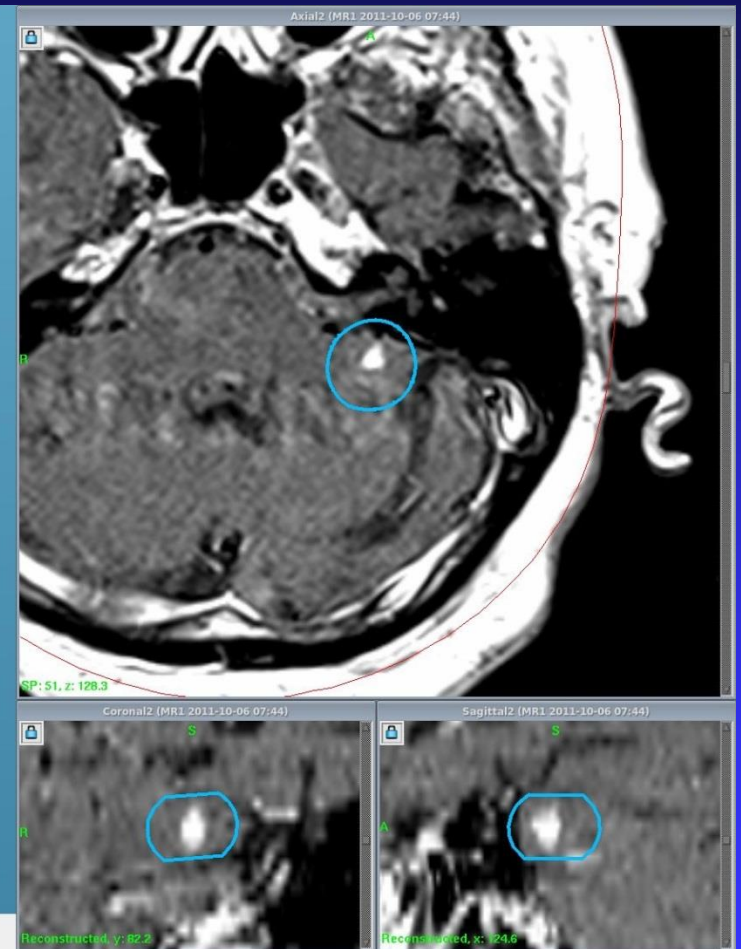
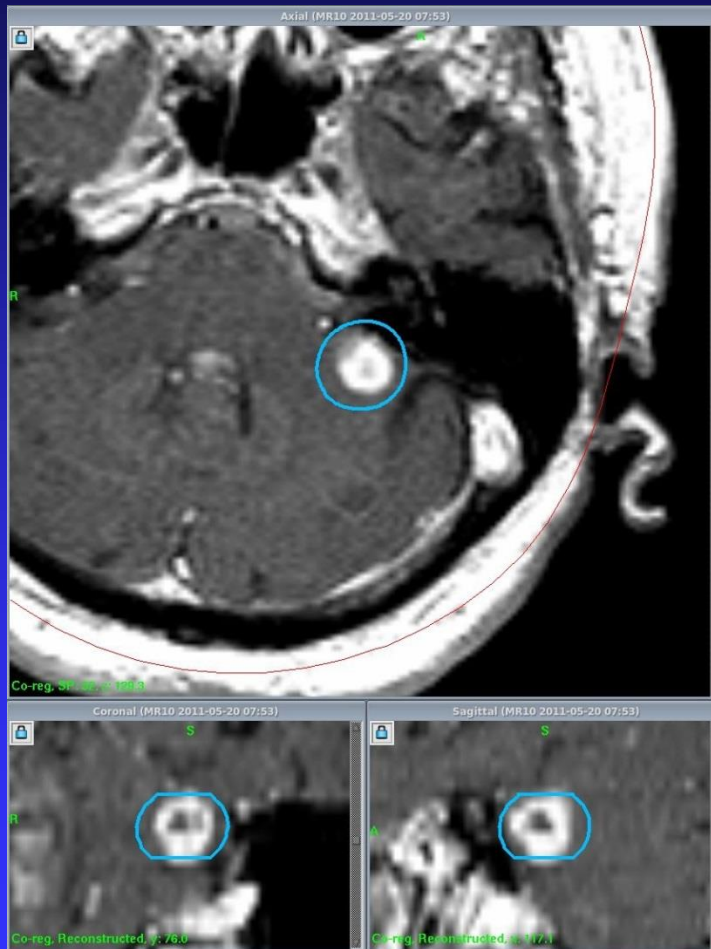
10 - years PFS grade I. 91%

10 - years PFS grade II. 88 %

late toxicity grade 310%,

in 6 pts. „late cystic formations“

High grade glioma



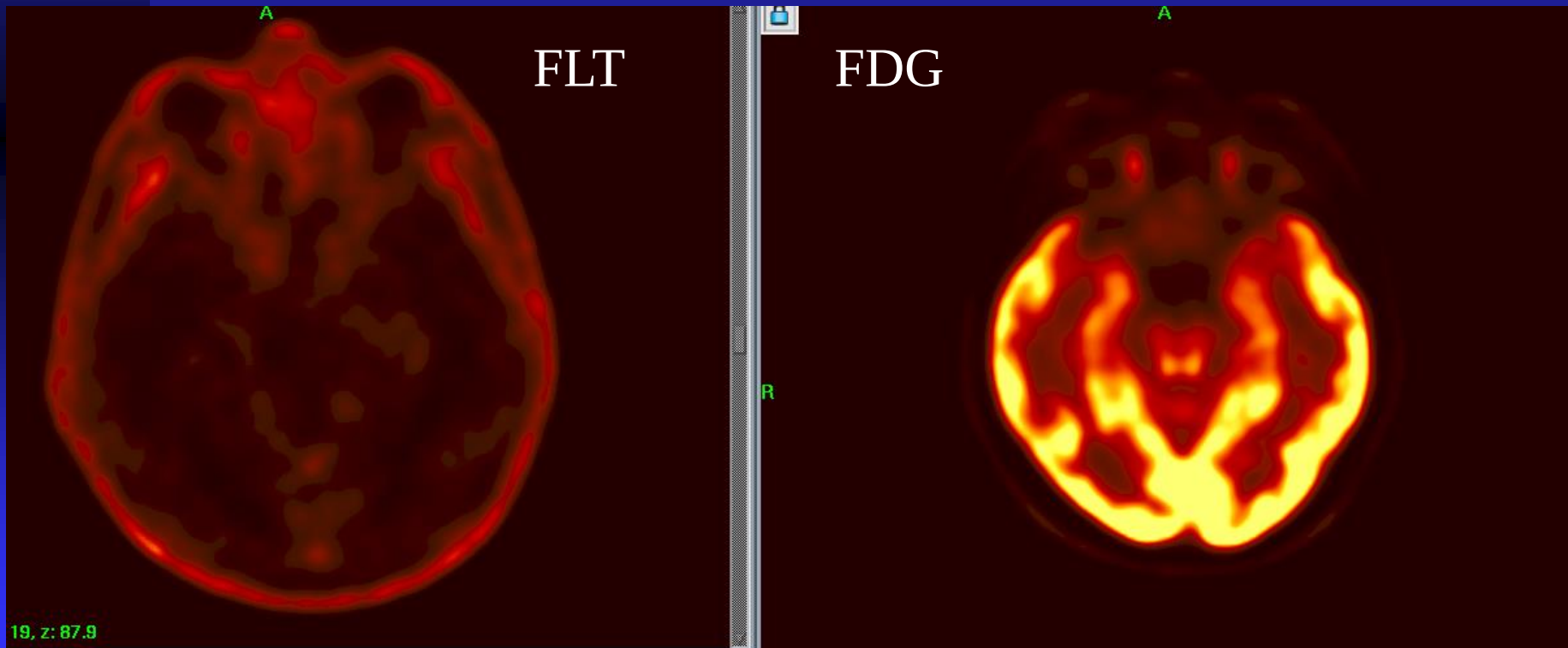
PET v plánování SRT recidiv po ozáření

■ „biologické plánování léčby zářením“

- **Metabolismus** (FDG) značené deriváty glukózy
- **Proliferace** (FLT) značený thymidin
- **Hypoxie** (Miso) deriváty misonidazolu
- **Methionin** GLIOMY
- **Tyrosin** (FET)
- Definice PTV (redukce PTV ?)

PET – různá radiofarmaka

Různá farmaka - různá informace!



PET v plánování SRT recidiv po ozáření

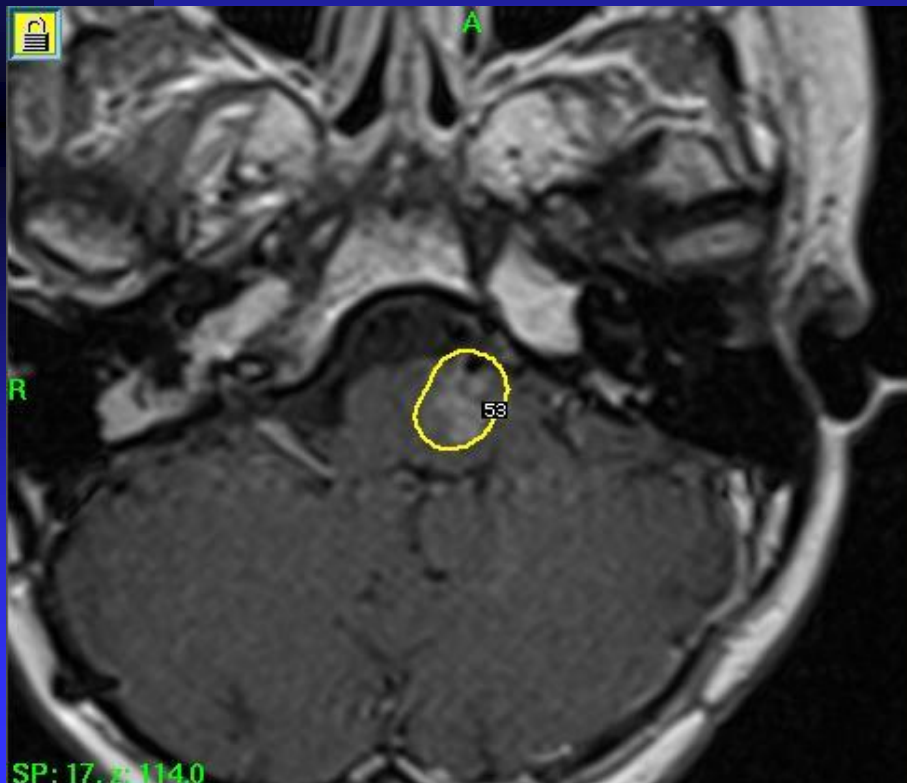
78 pacientů

- recidivy po EXBRT, NCH nebo SRT
- kontrolní PET za 6 měsíců po ozáření
- ca nasopharyngu
- prim. a sek.mozkové nádory
- rozdíly v GTV (MR, PET) až 30%
- prospektivní studie

FLT PET

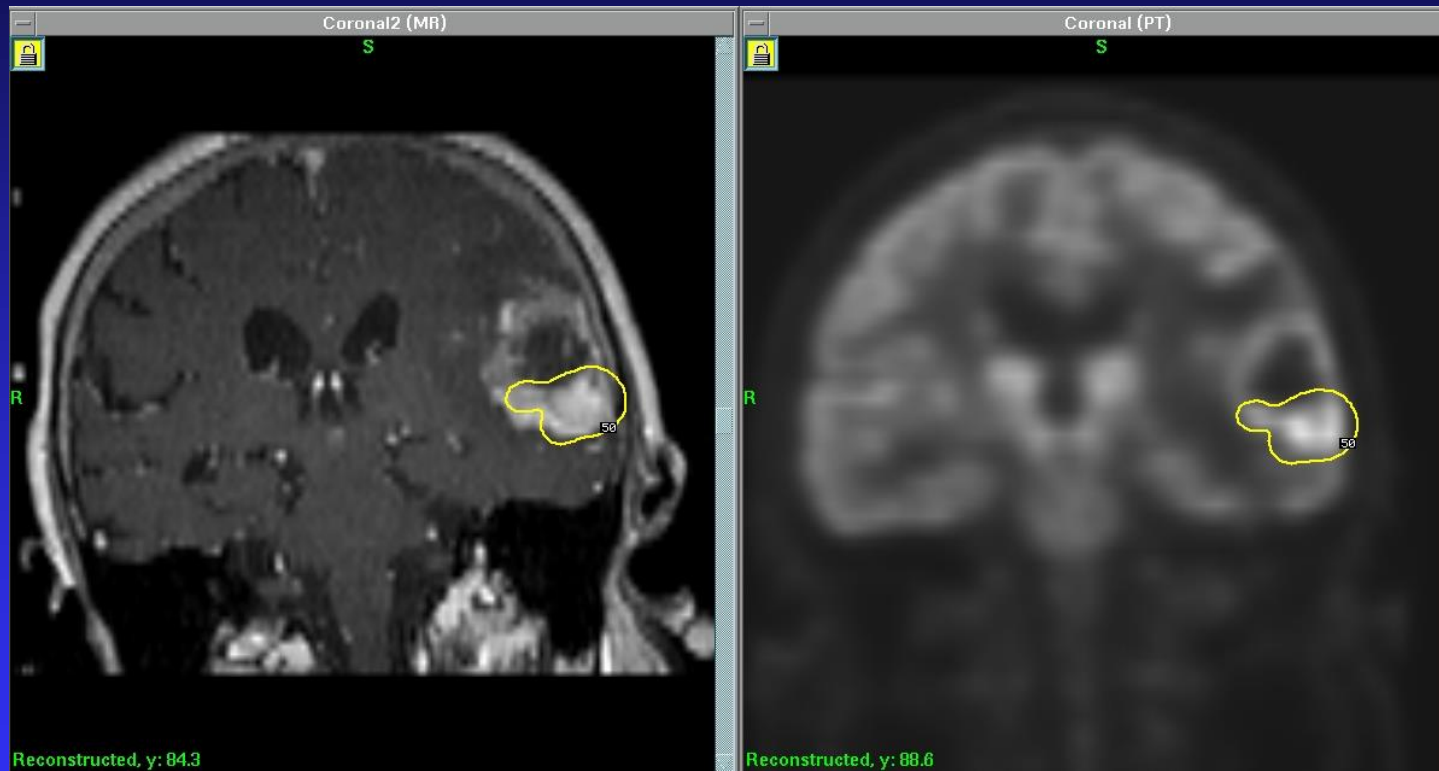
**Recidiva anaplastic.ependymomu kmene vlevo
(stp parc. NCH resekci, EXBRT 54 Gy, stp CHT)**

- SRT 5 denní frakcionace,
- D min 4,2 Gy,
- total D min 21 Gy

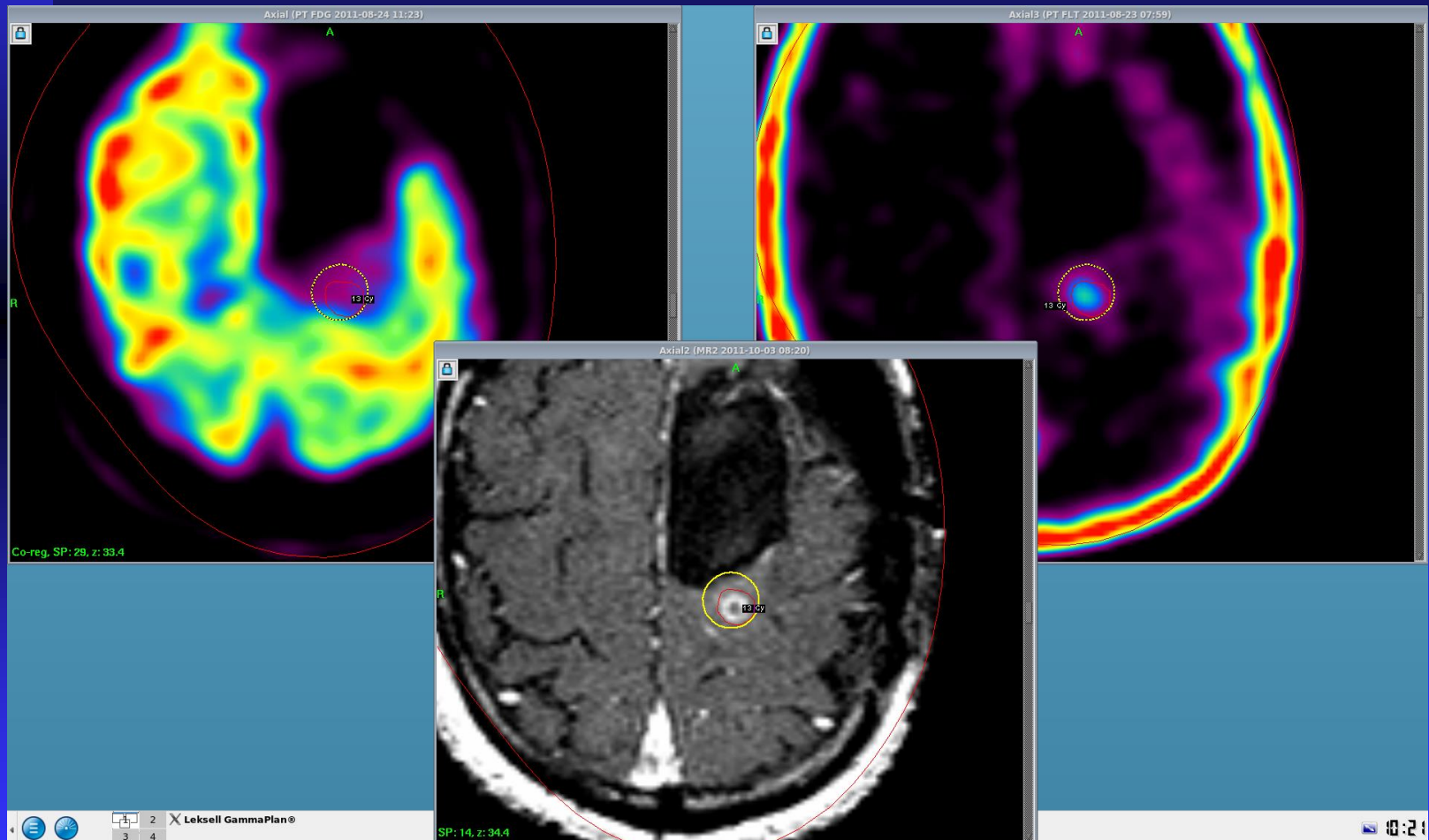


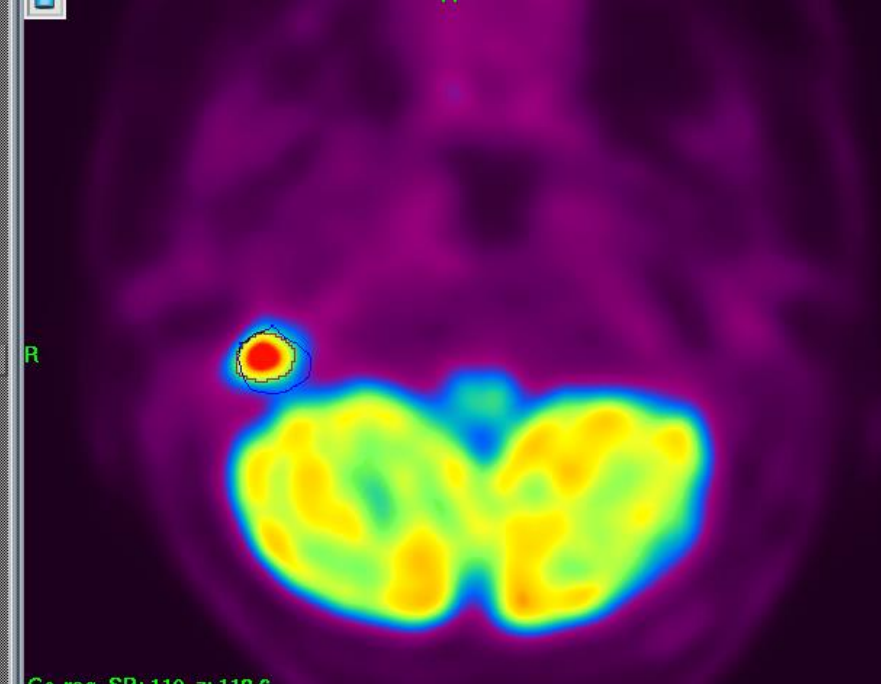
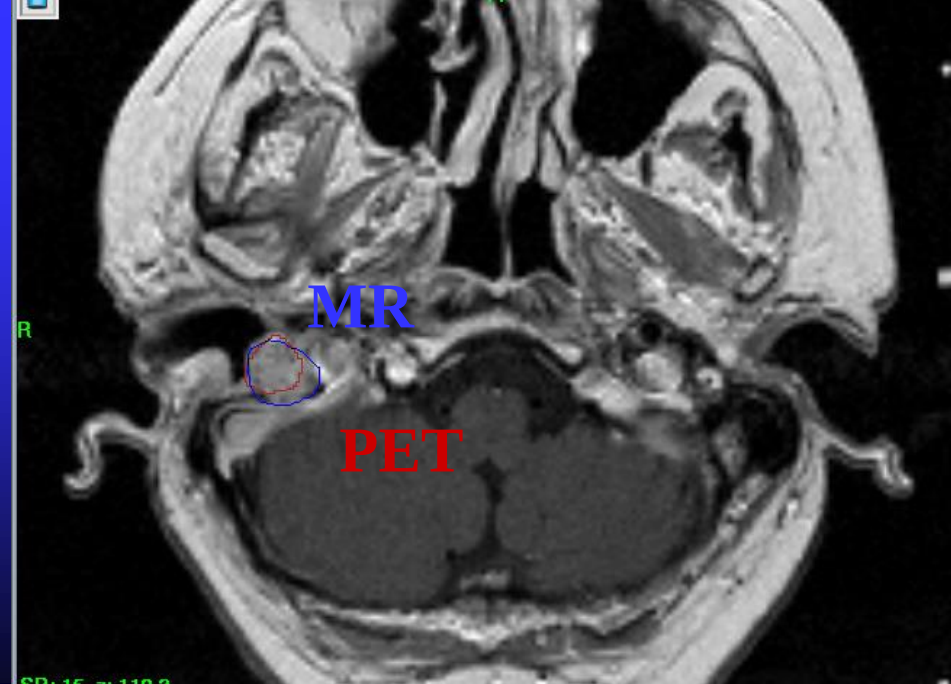
MRI and PET planning

local recurrence of metastasis (12 months after LGK)

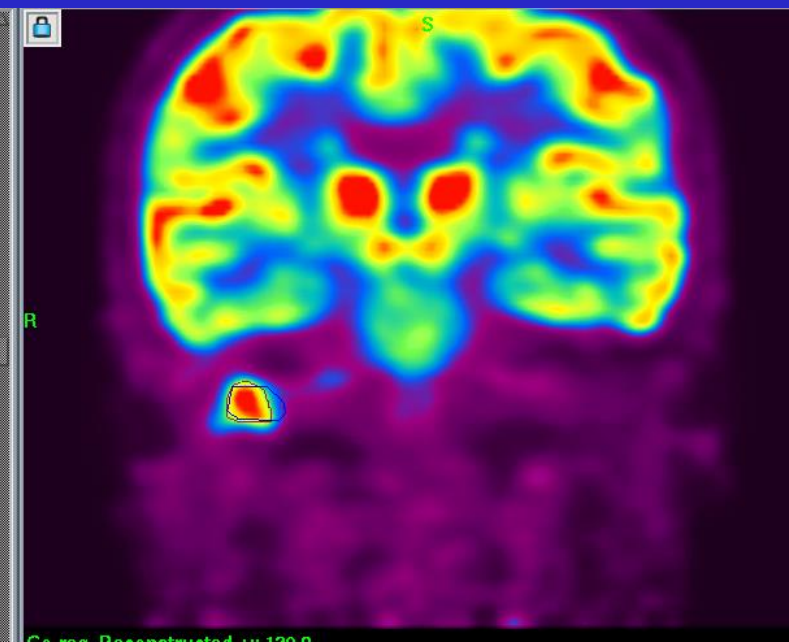
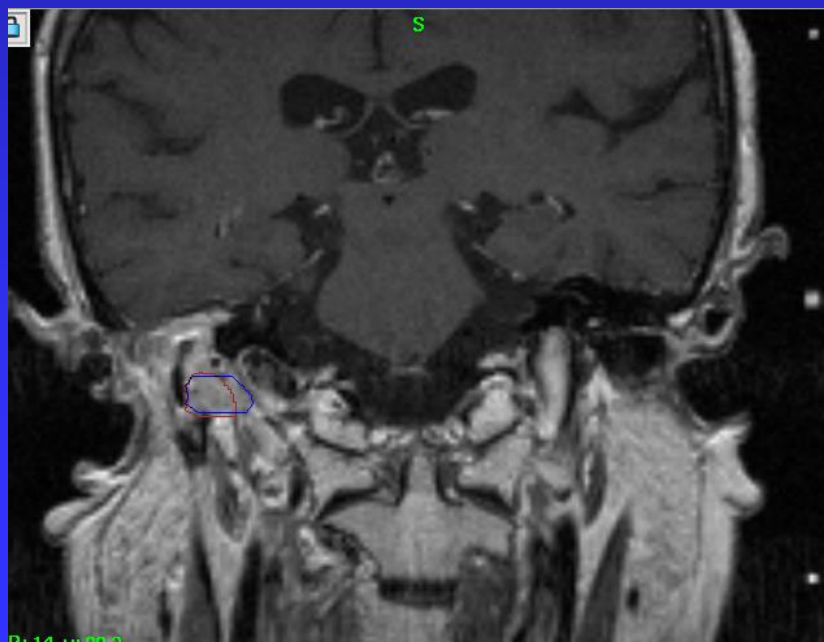


PET plánování:HGG





PET FDG Spinocellulární karcinom

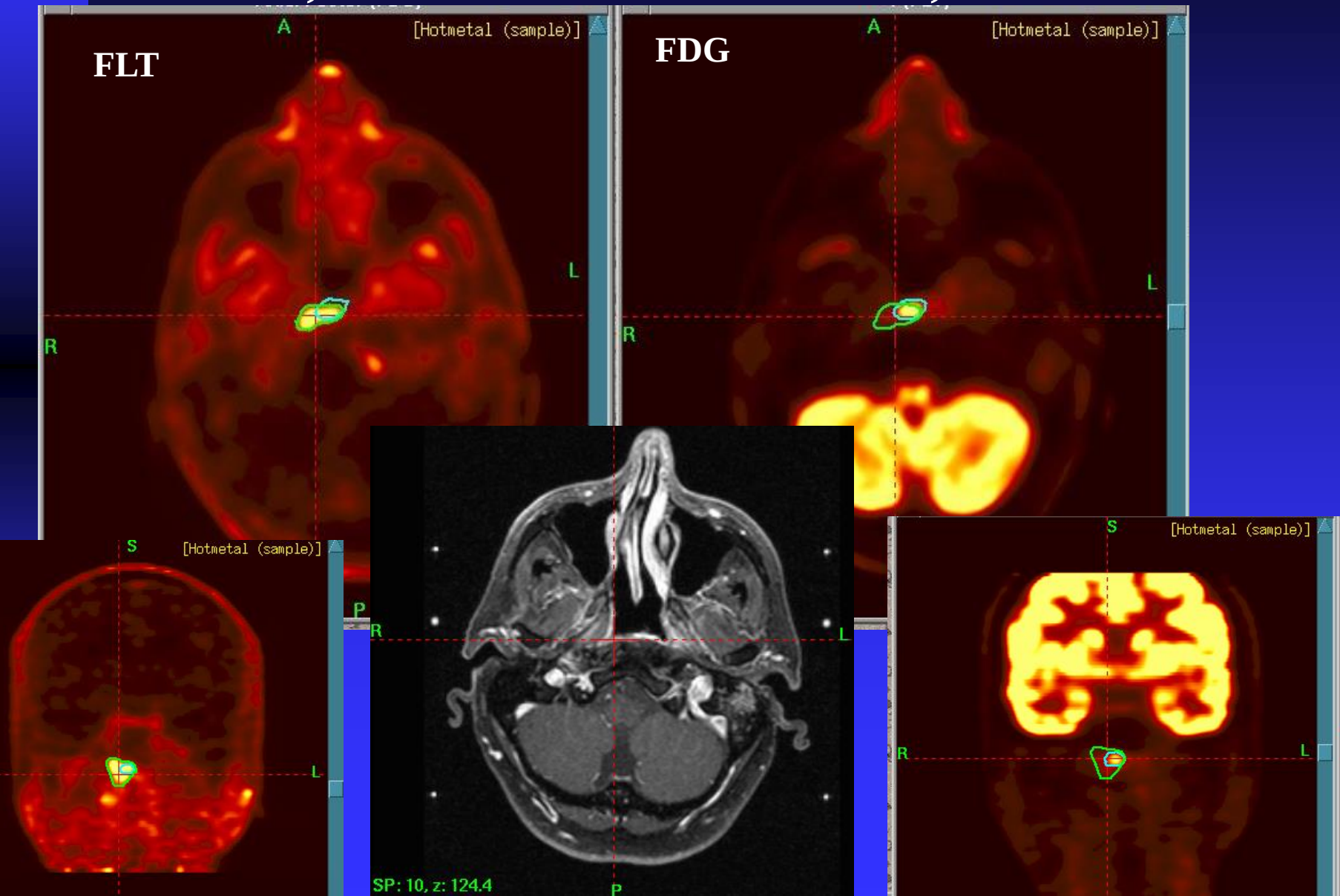


PET FLT,FDG –plánování SRT

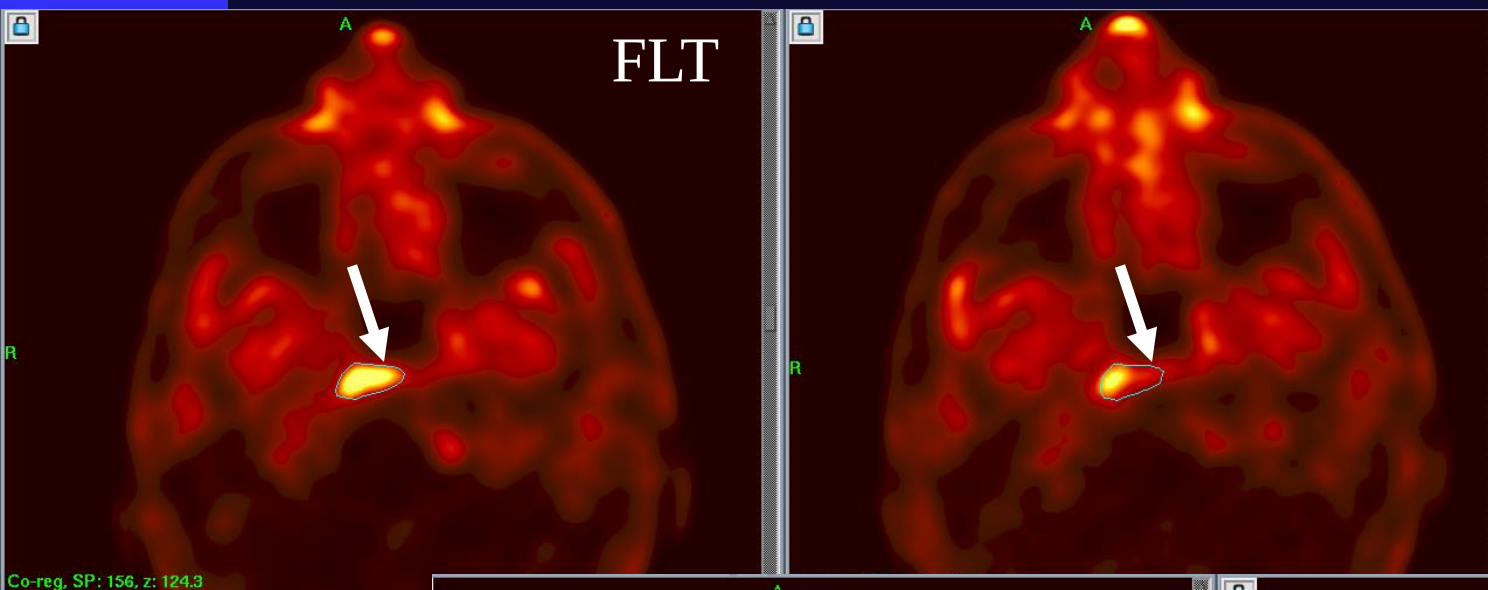
rec.ca nasopharyngu

GTV FLT 1,7 cm³

GTV FDG 0,513 cm³



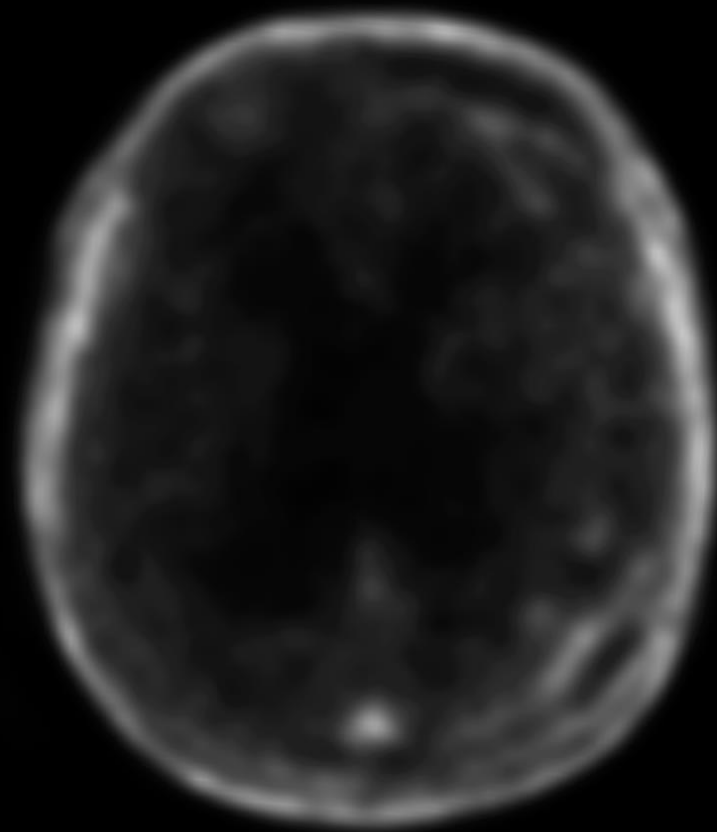
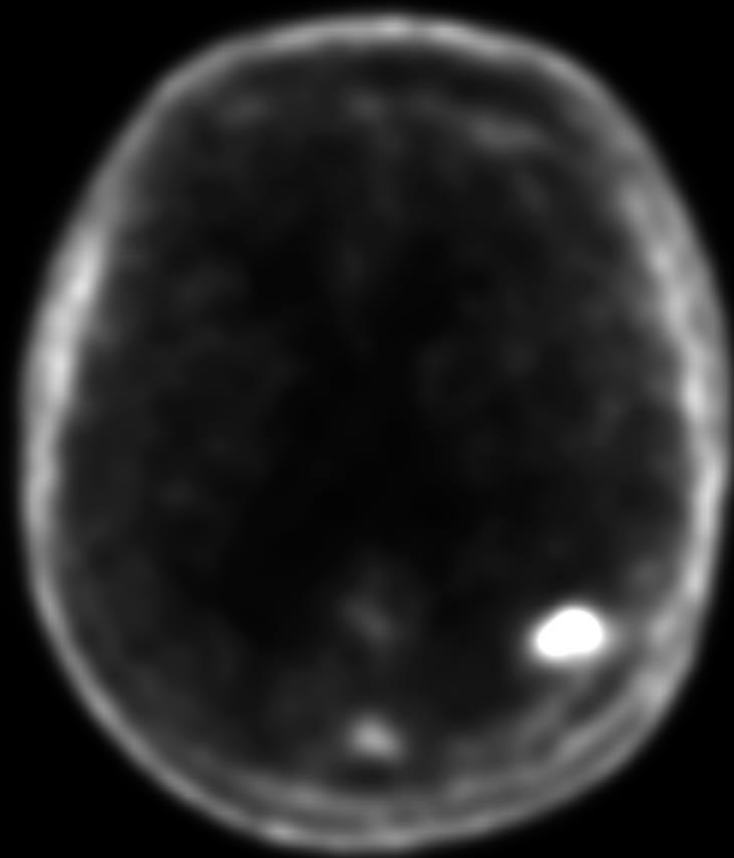
PET –FLT, FDG kontrola 4 měsíce po ozáření



Kontura
reprezentuje ozář.
GTV

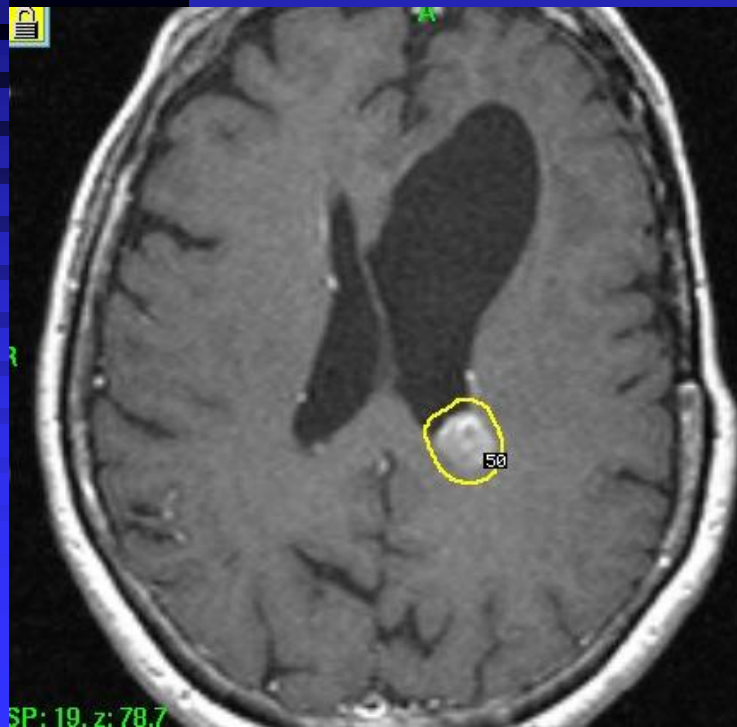
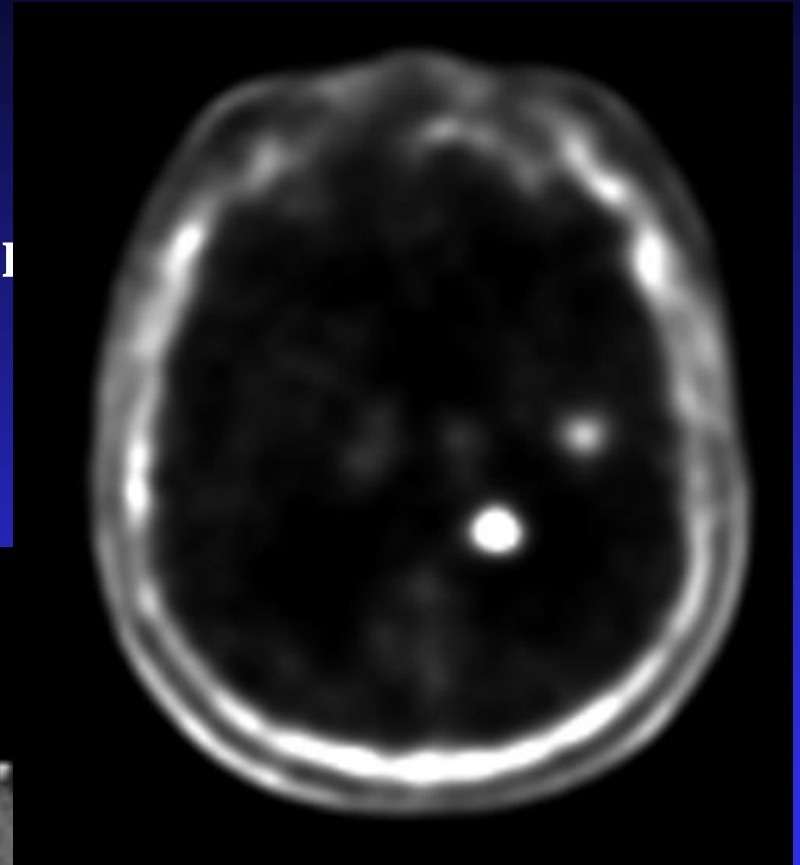


PET v diferenciální diagnostice recidiv po ozáření na LGN



FDG PET v plánování SRT recidiv po ozáření

anaplastic.astrocytom.reg.F-P sin
pozit.FDG,FLT PET mozek
nová léze



Material and method

126 treated patients during 8 years with minimal follow up 6 years (uveal melanoma)

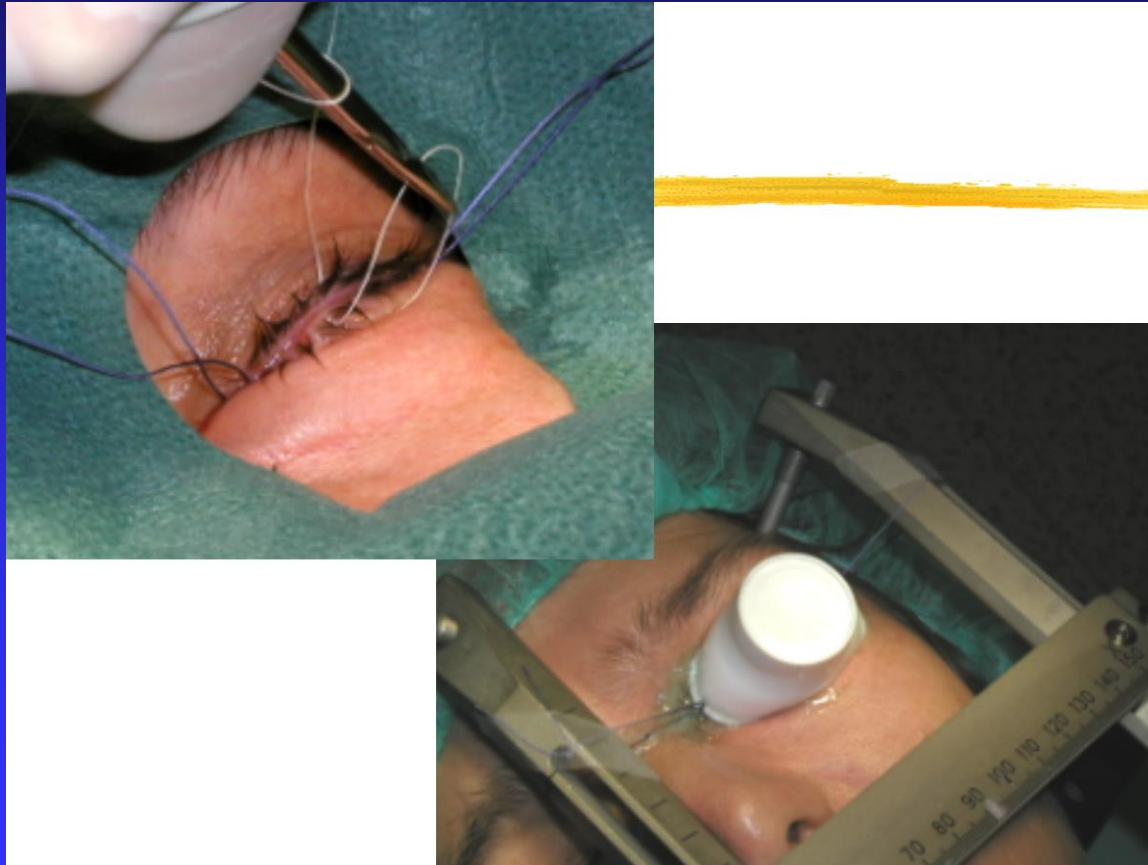
- Median age 59 years
- Median of tumor height 8 mm (1-20)
- Median of GTV 551 cmm (33- 7 800)
- Median of PTV 1 300 cmm (67-8200)
- Median of minimal single dose 34Gy(28-85)
- The location of tumor was anterior to equator 14%, posterior to equator 59 % and on both these sides in 25%.

Material and method

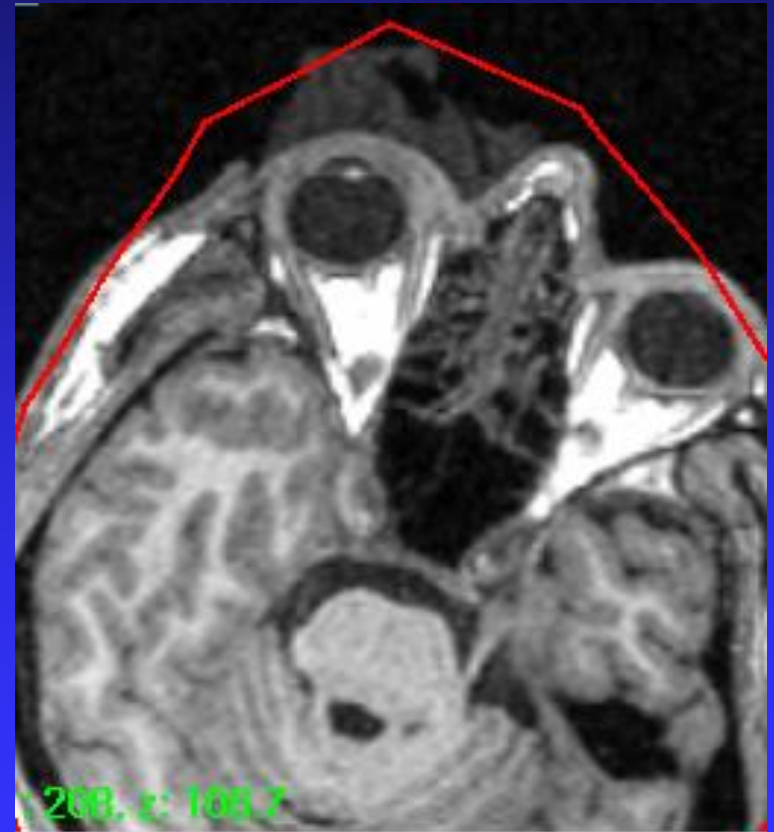
■ **Diagnosis**

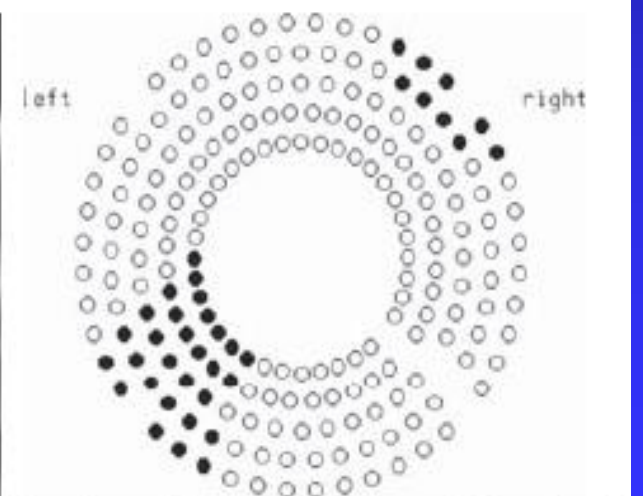
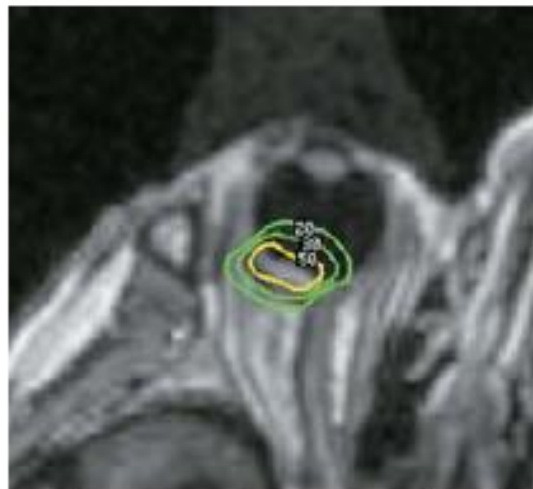
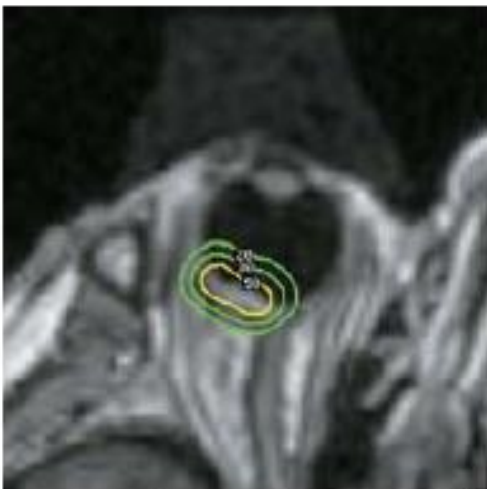
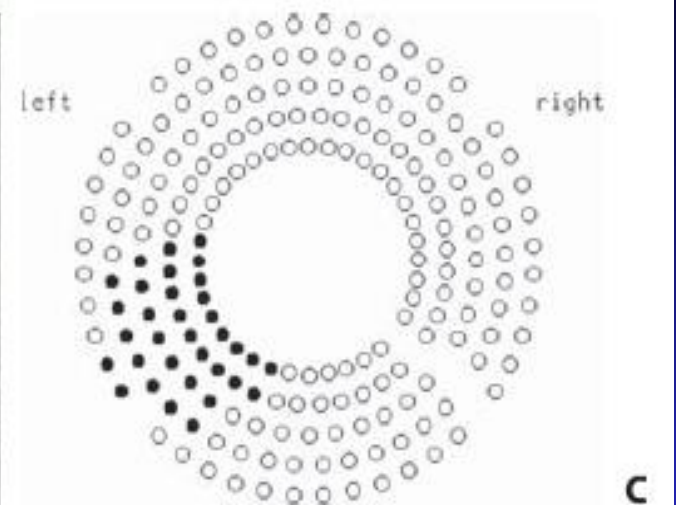
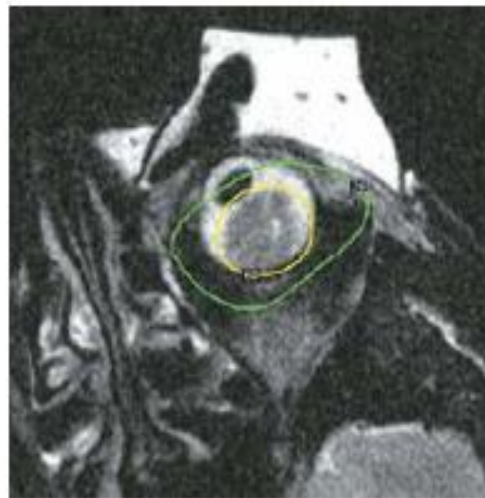
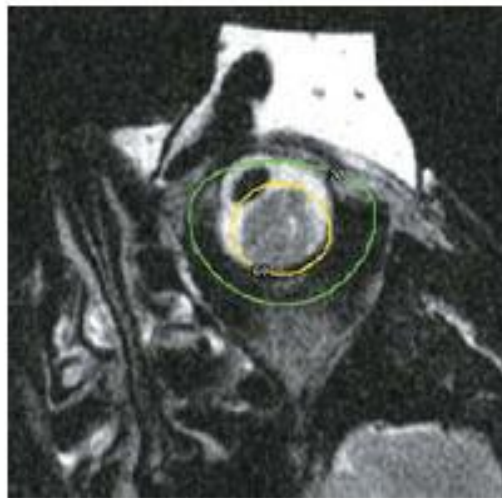
- ultrasonography
- complete ophthalmological examination
- CT or NMR of liver and chest
- NMR T1 W and T2 W native, post contrast T1 and post contrast 3D 1,3 mm thickness

The eye fixation, build up application



The fixation of stereotactic frame and application of build up (NMR scan)





Local tumor response (results)

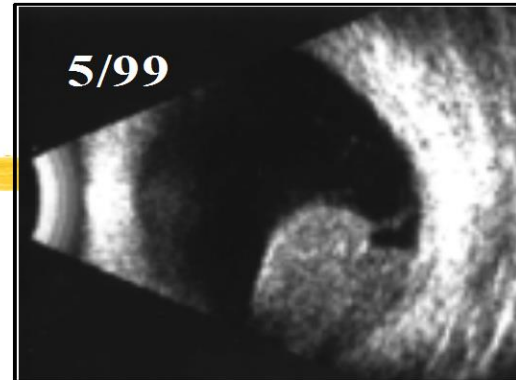
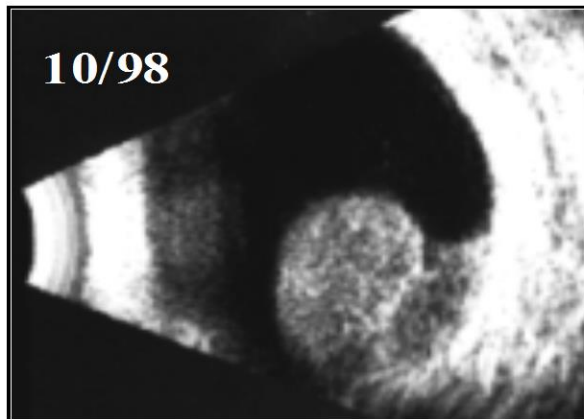
- The majority of tumor response 24 months after irradiation)
- **complete and partial regression** 76%
- **stabilization** 14%
- **progression** 10%

Late complications

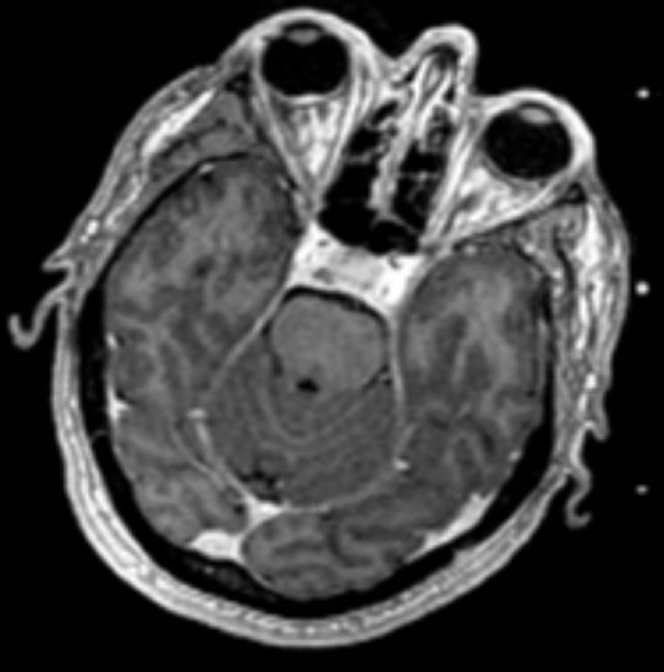
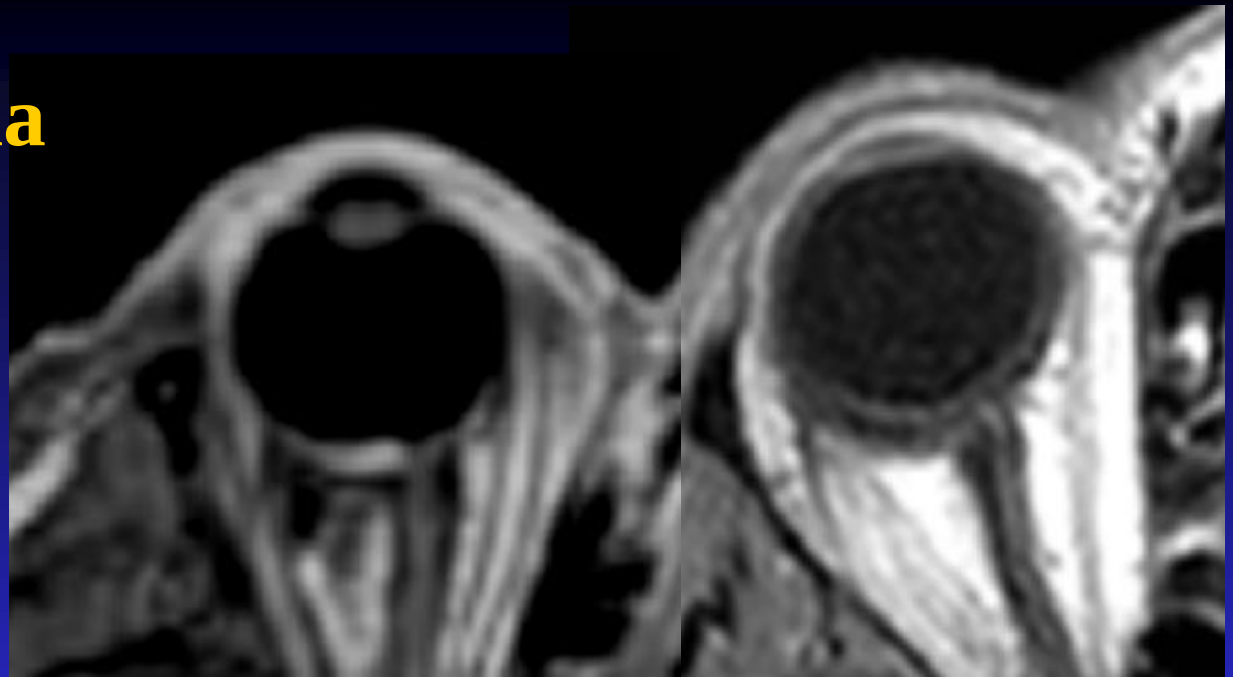
LENT SOMA scoring system RTOG/EORTC

- cornea gr.3,4 D max 10 Gy..... 3 %
- lens gr.3,4 D max 7 Gy..... 8 %
- retina gr.3,412 %
- iris gr .3,4 D max 15 Gy.....5 %
- The most serious late complication was neovascular glaucoma.
- sec.glaucoma.....21 %
- (significant lower incidence for PTV less than 1 000mm³)

Uveal melanoma ultrasonography and controls 8 and 17 months after treatment

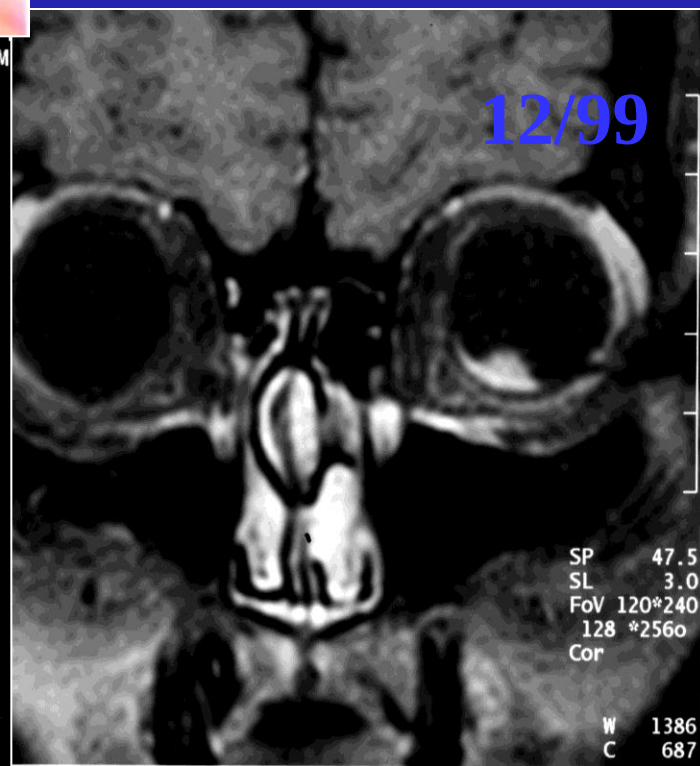


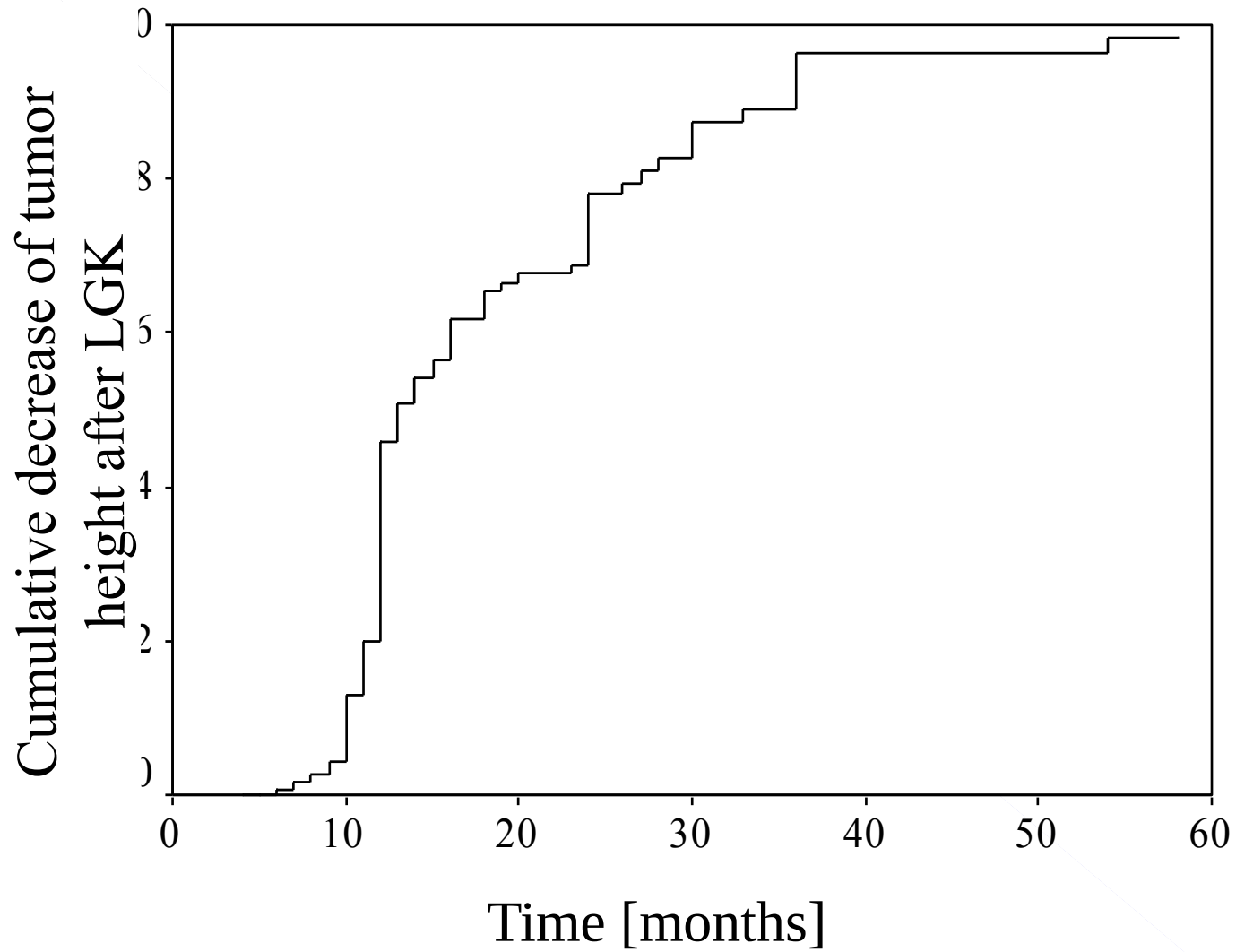
Uveal melanoma

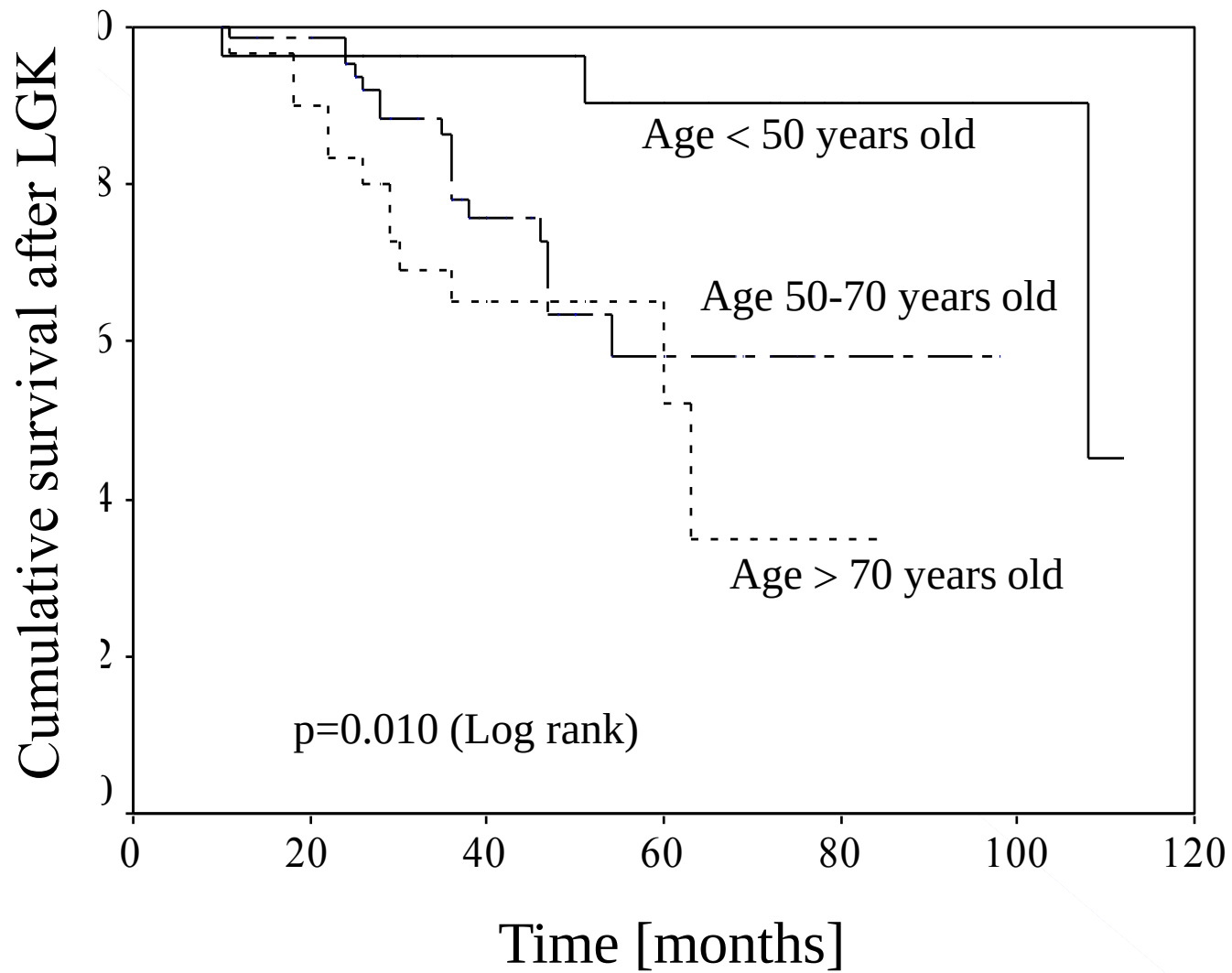


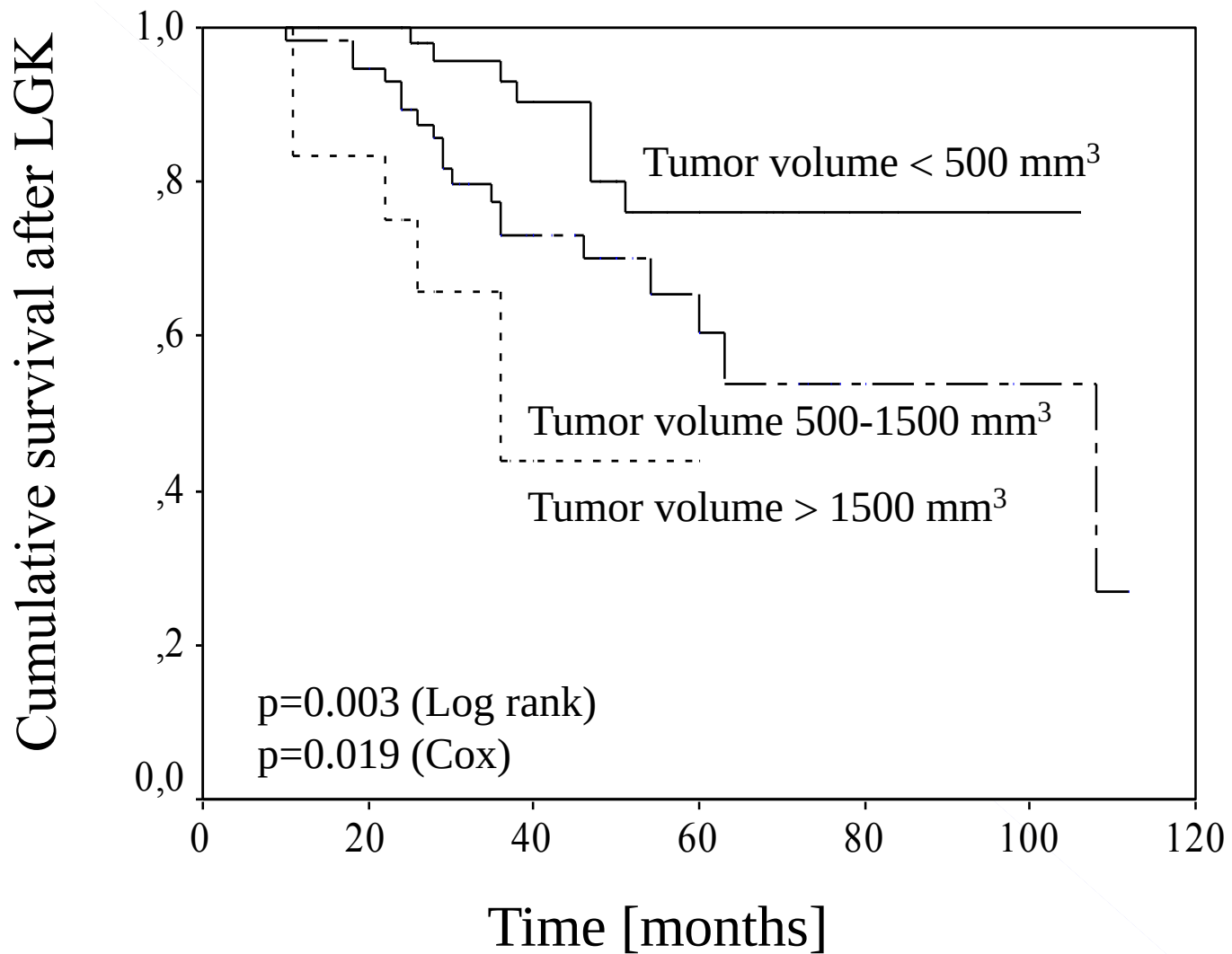
**24 months
after LGK**

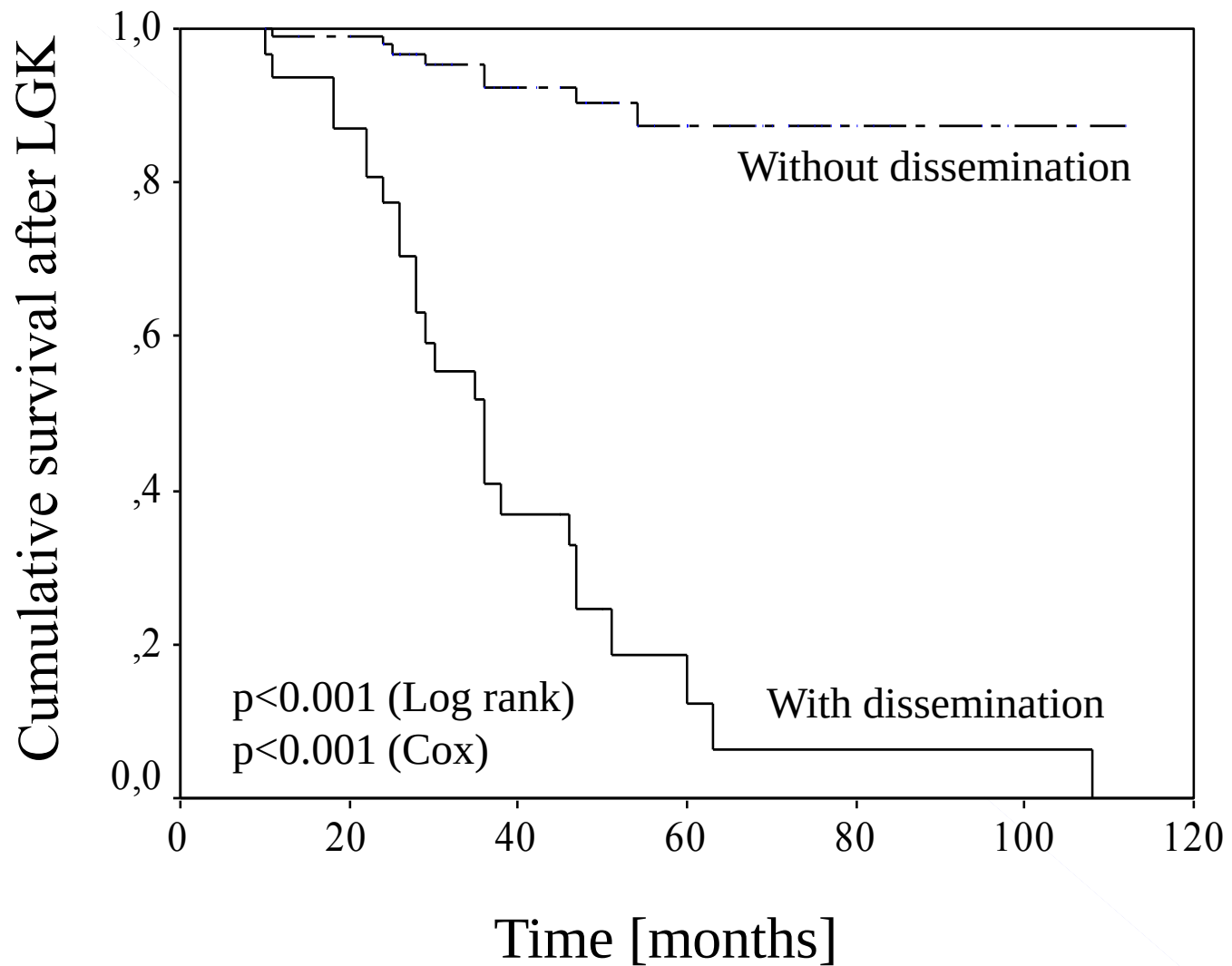
Local tumor response







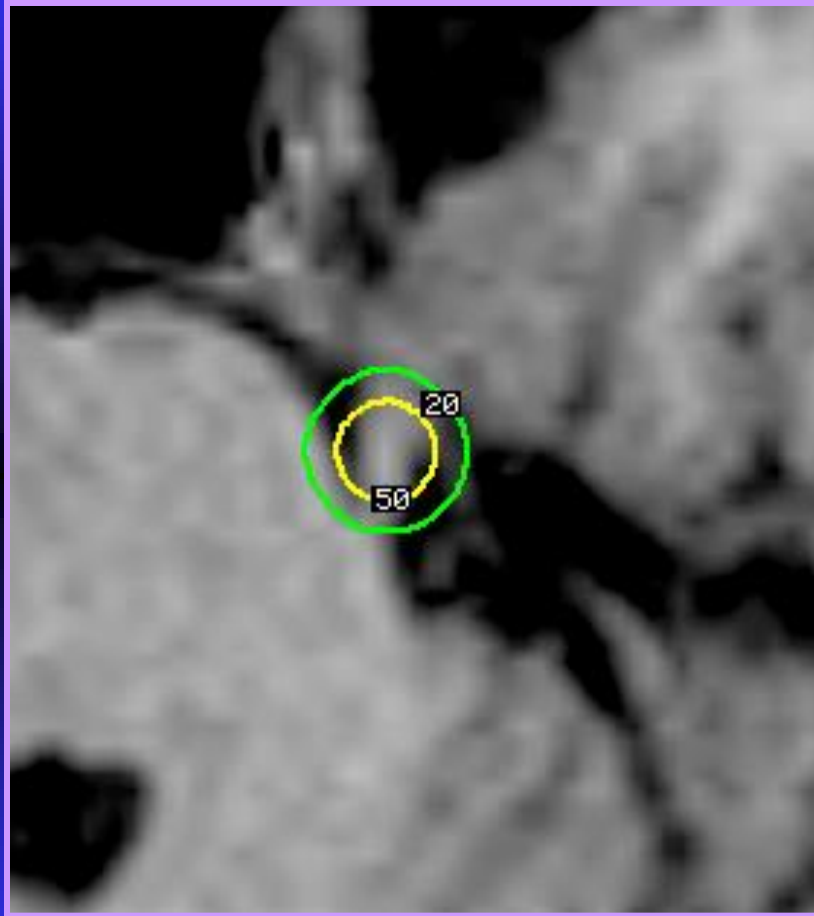




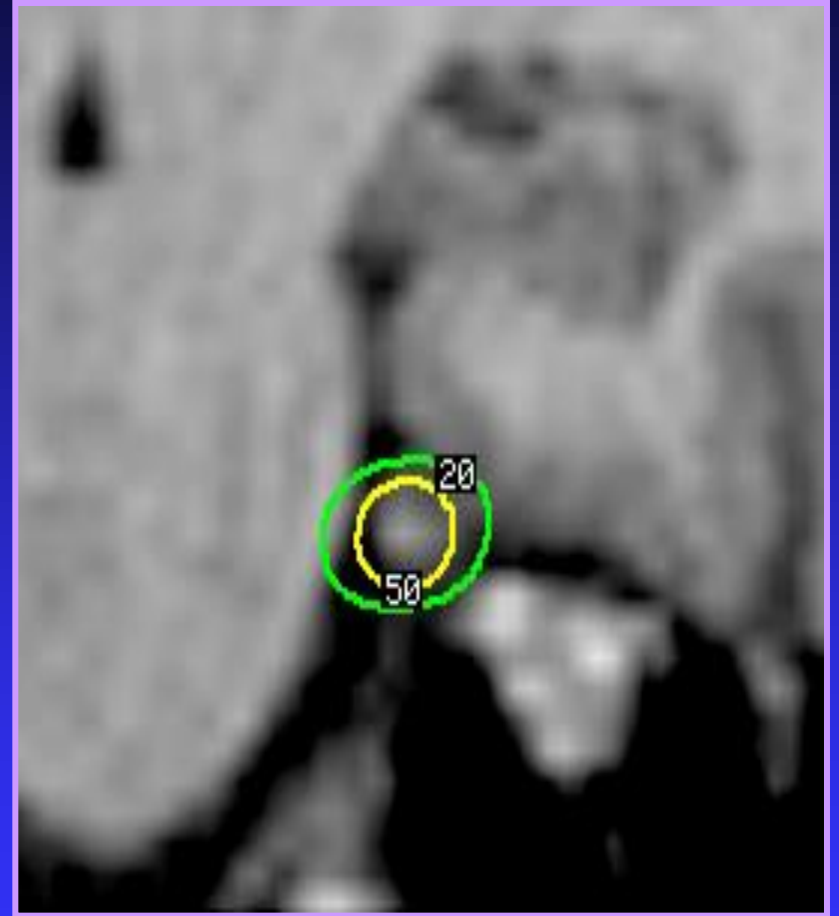
Favourable group

- Patients younger than 50 years, with pre equatorial location of the tumor, tumor height not exceeded 5 mm, gross tumor volume (GTV) not larger than 500 cmm and with no other organ dissemination.

Trigeminal neuralgia



axial
slice



coronal
slice

Radiosurgery, stereotactic radiotherapy(brain): local tumors control

- **Benign tumors 85-90%**
- **Malignant-brain metastases : 75%**
- **Acute complications 15-20%**
- **Late complications 5%**