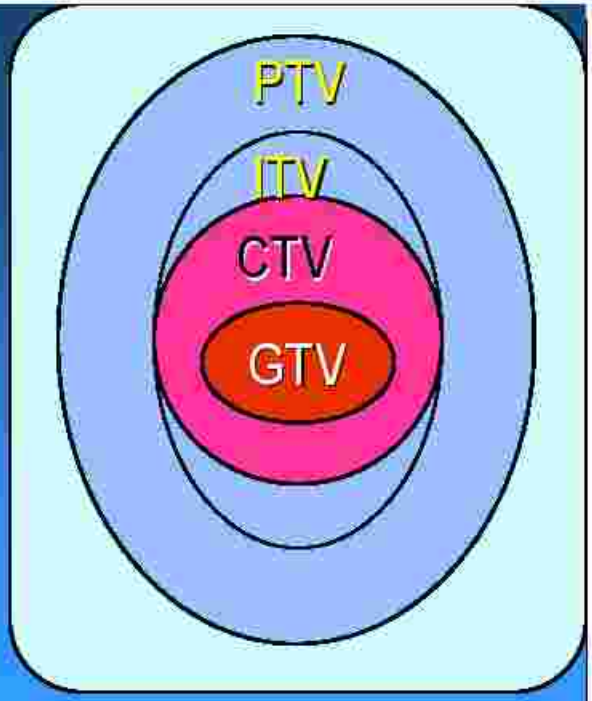
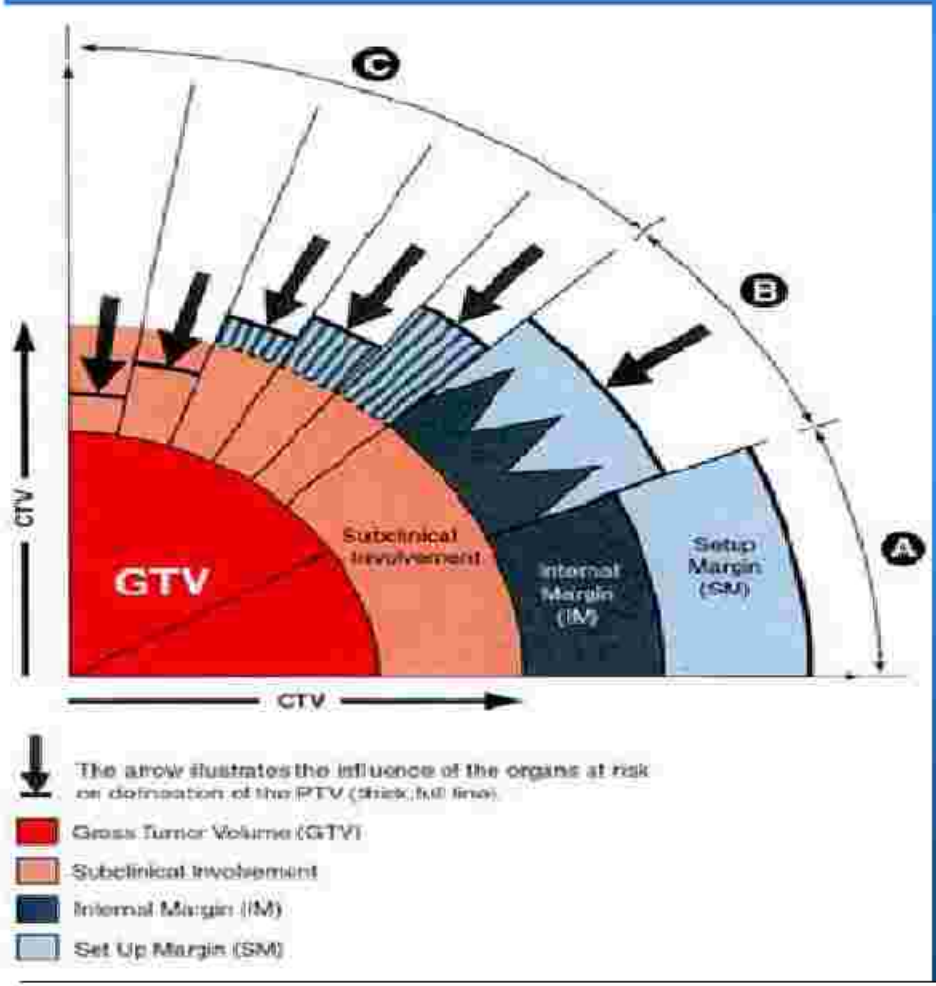
Target Volume delineation

ICRU 62





GTV = Visible tumour and areas deemed to contain tumour

CTV = microscopic extension

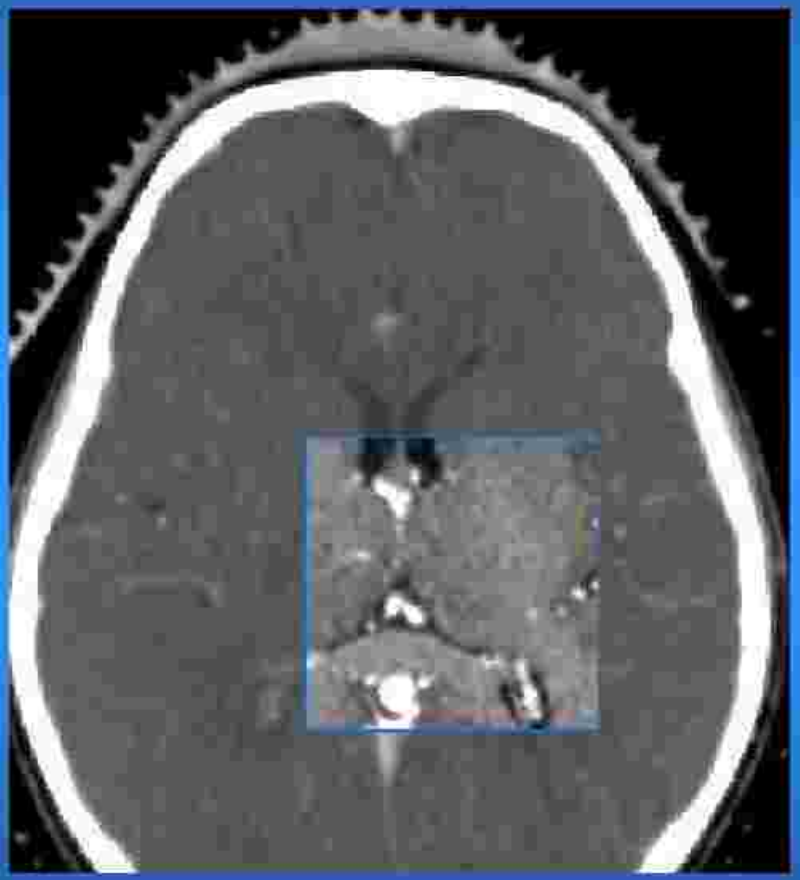
Internal Target Volume (ITV) = CTV + Internal margin (IM)

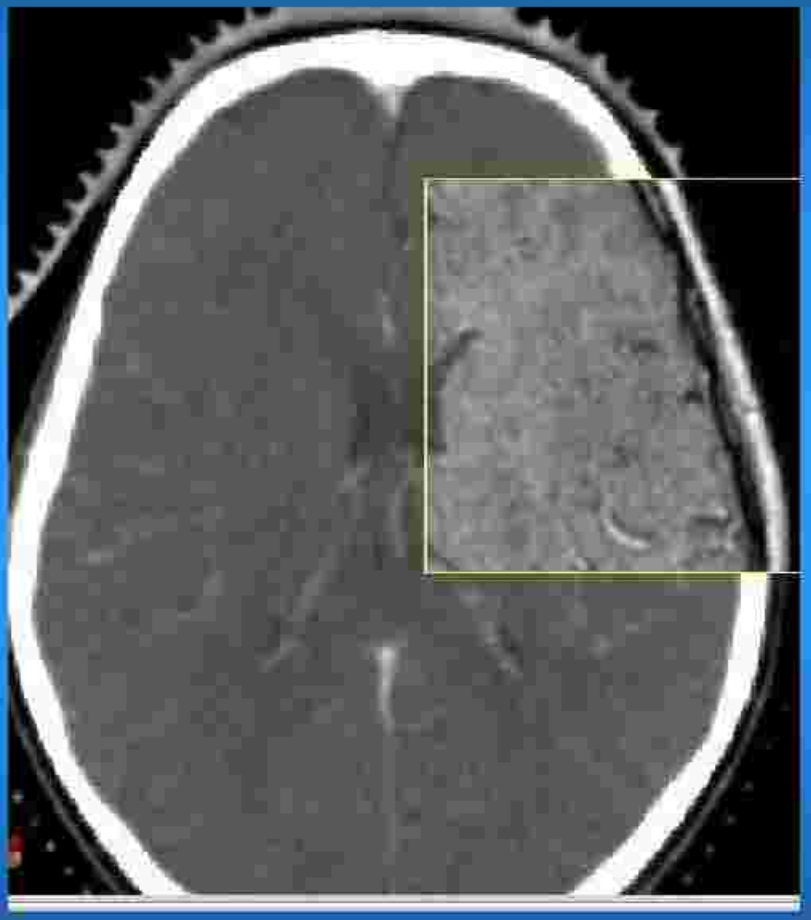
PTV = ITV + Set up margin (**SM**)

Imp points in Imaging for brain tumours

- CT scan alone should not be used, try to use MRI as well
- MRI – T1 contrast; T2/FLAIR sequences, thin slices, if preop MRI available- great for fusion; sag and coronal also, if possible
- 3D FSPGR sequence 1-3 mm slices with excellent resolution
- Equal matrix size (256x256), not oblique and equal spacing for MRI
- important to check accuracy in CT/MRI fusion/co-registration (basilar artery, lens, IIIrd ventricle as common anatomical structures)
- Biological imaging
  - Magnetic Resonance spectroscopy (MRS)
  - Positron Emission Tomography (PET)

Image Fusion





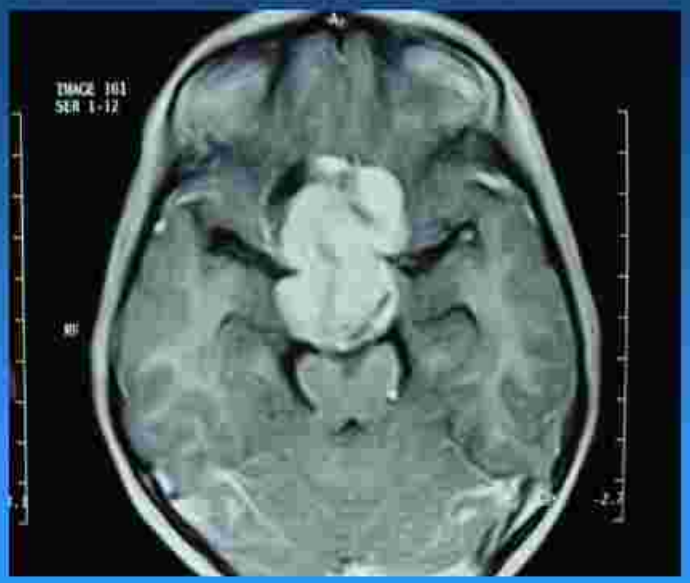
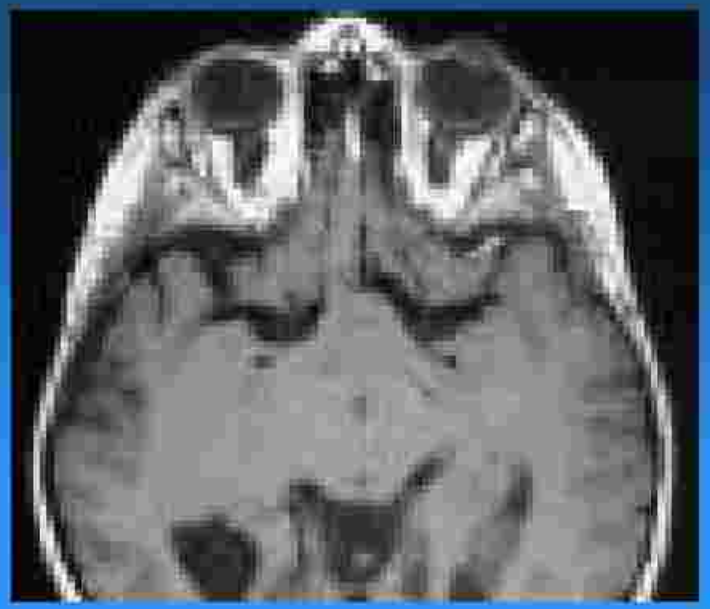
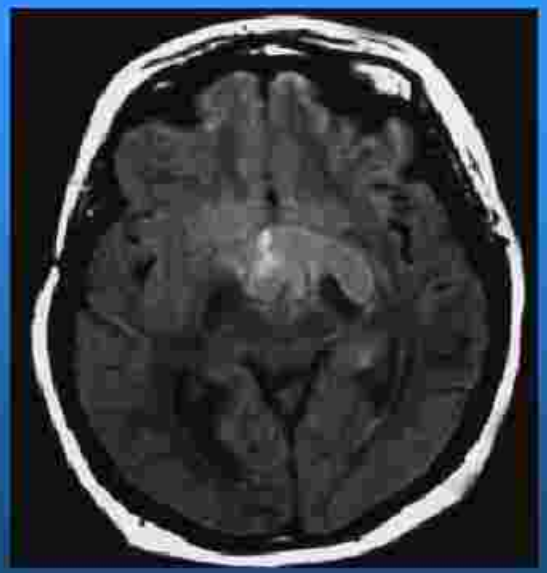
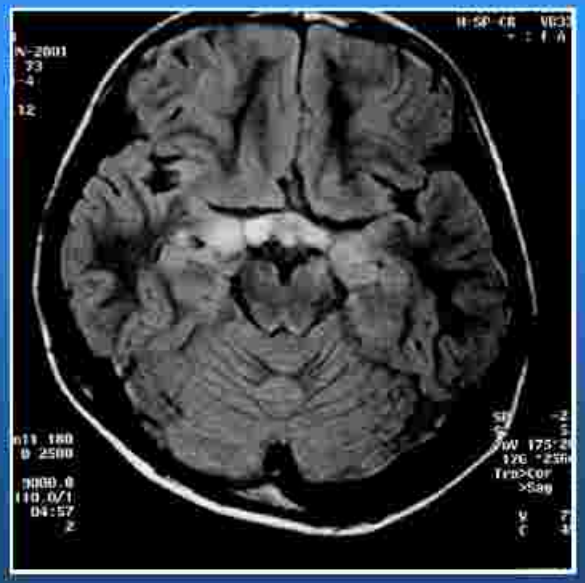
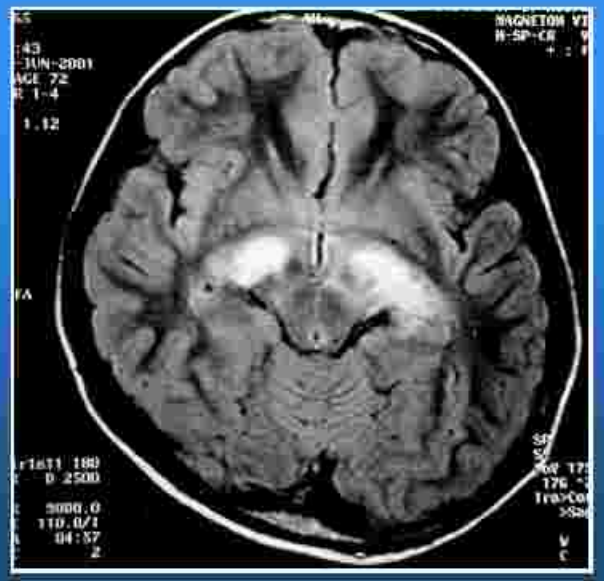


IMAGE 101
SER 1-12



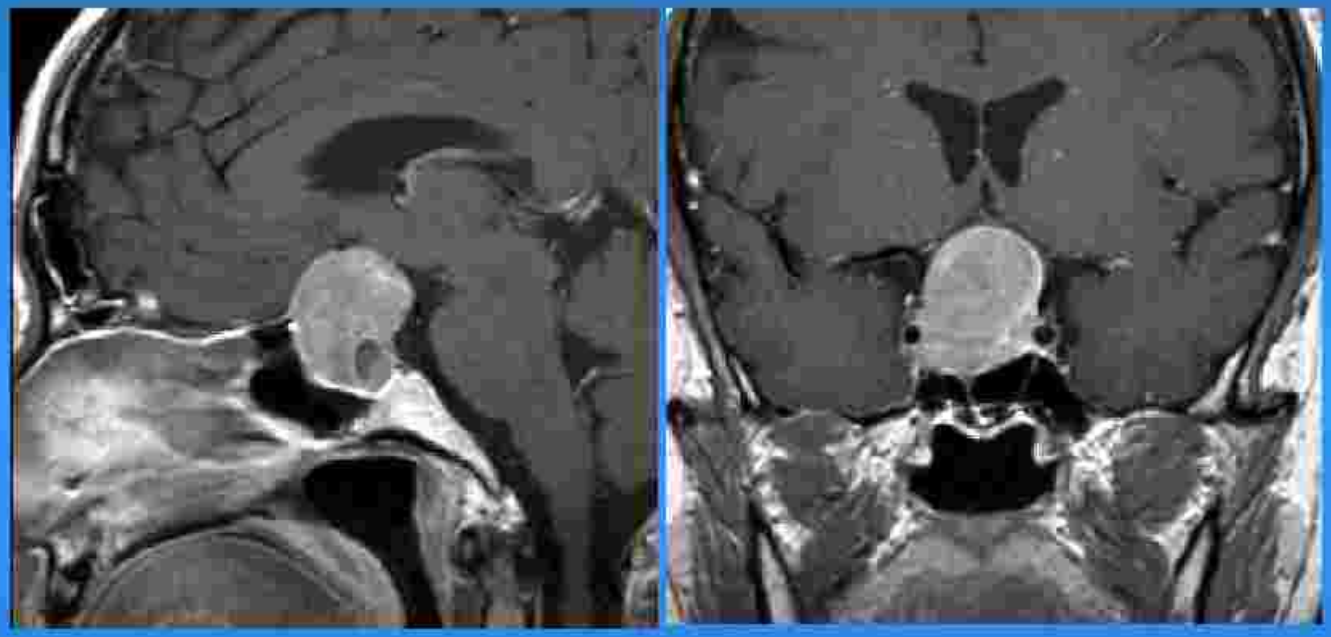






Important points before contouring

- Ensure high resolution planning scans, preferably with adequate contrast administration
- Review all pre-operative and post-operative scans in detail
- Good knowledge and experience in the tumour characteristics seen on radiology and anatomy
- When in doubt, discuss with the neurosurgeon and the radiologist
- high grade tumours (Gliomas, medullo, ependymoma), **MUST** do a post op scan within 24-48 hours
- For benign tumours, TREAT WHAT YOU SEE, so do a scan and plan RT 6-8 weeks post op.



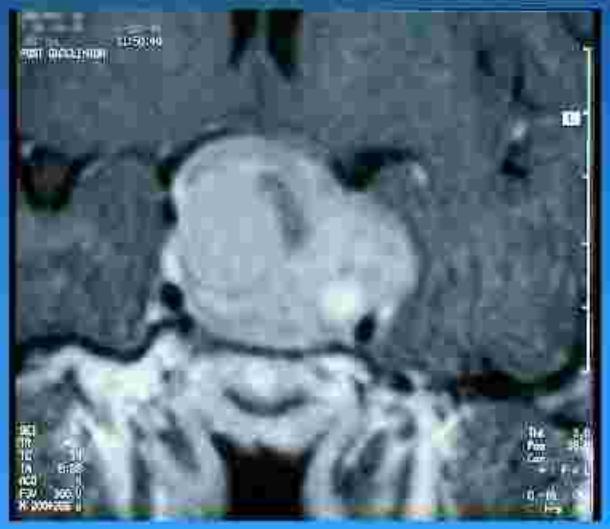
Results after Surgery

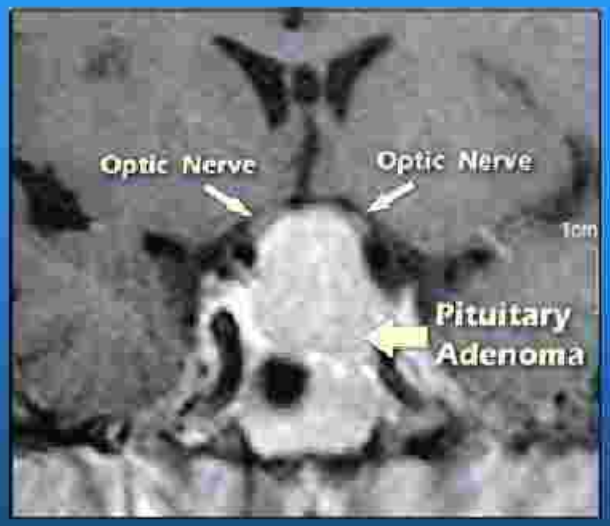
After surgery alone, the regrowth rates are between 10 to 75%
RT reserved for large/invasive/recurrent cases

Study	Follow-up period	Recurrence rate after surgery (%)	Recurrence rate after surgery + RT (%)
Ciric *et al.*, 1983 (7)	6 months–14 years	28	6
Ebersold *et al.*, 1986 (8)	4 years–8 years	16	9
Chun *et al.*, 1988 (9)	2 years–18 years	19–22	2–10
McCollough *et al.*, 1991 (11)	5 years–21 years	N/A	5
Comtois *et al.*, 1991 (12)	1 year–16 years	21	N/A

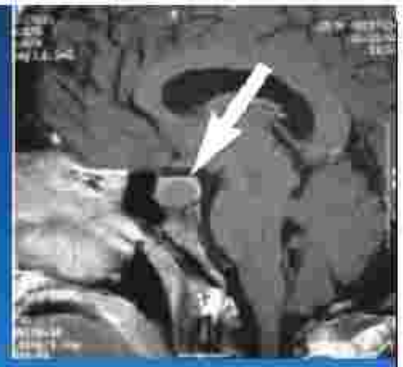
Radiotherapy

- Large residual disease
- Cavernous sinus invasion
- Suprasellar invasion
- Aggressive histology
- Recurrent tumours





Modern surgery – best cases



132 patients, 98 were advised postoperative observation

- no radiologic or surgical evidence of parapituitary invasion
- complete surgical removal
- absence of suprasellar extension 2 months postoperatively
- no histologic feature of aggressive tumour behaviour (mitoses or poor cellular differentiation)

21 of 65 (32%) patients progressed at follow up of 20 years

Bradley Clin Endocrinol 1994

Need for RT?

Role of radiotherapy has been questioned

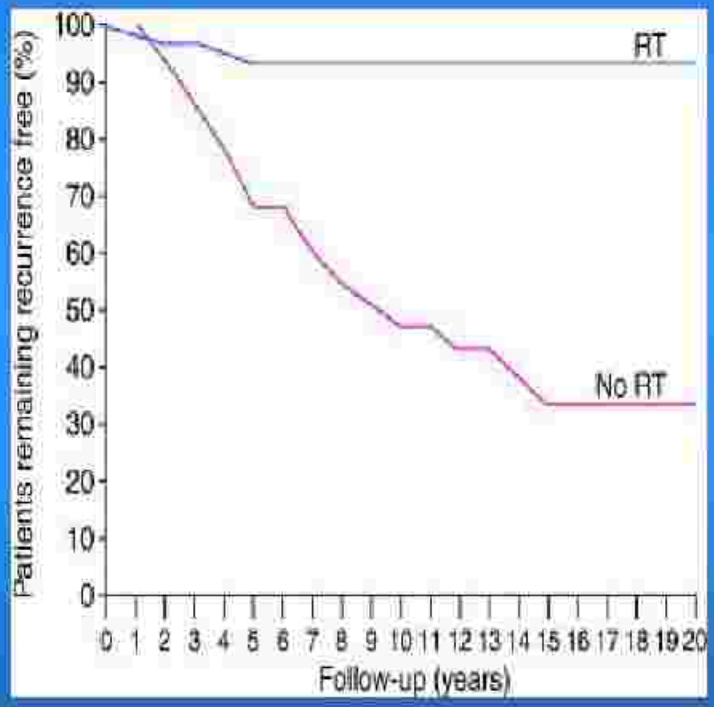
- Fear of RT complications
- Fear of increased morbidity for re-operations
- Lack of randomised data
- Will re-excise at recurrence (?morbidity/mortality)
- Better results with modern radiological and surgical techniques

Best non randomised data

Comparative study of 2 surgical institutions; same RT set up

PFS	RT *n=63*	No RT *n=63*
5 yr	93%	68%
10 yr	93%	47%
15 yr	93%	33%

Administration of RT was the only significant factor



Gittoes Clin Endocrinol 1998

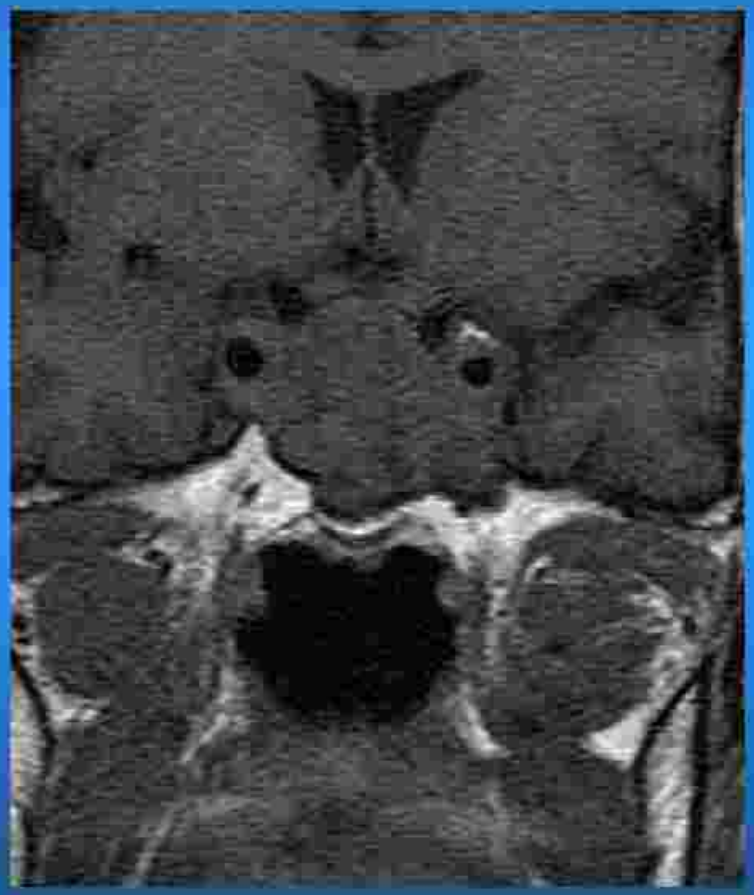
RT in functioning tumours acromegaly

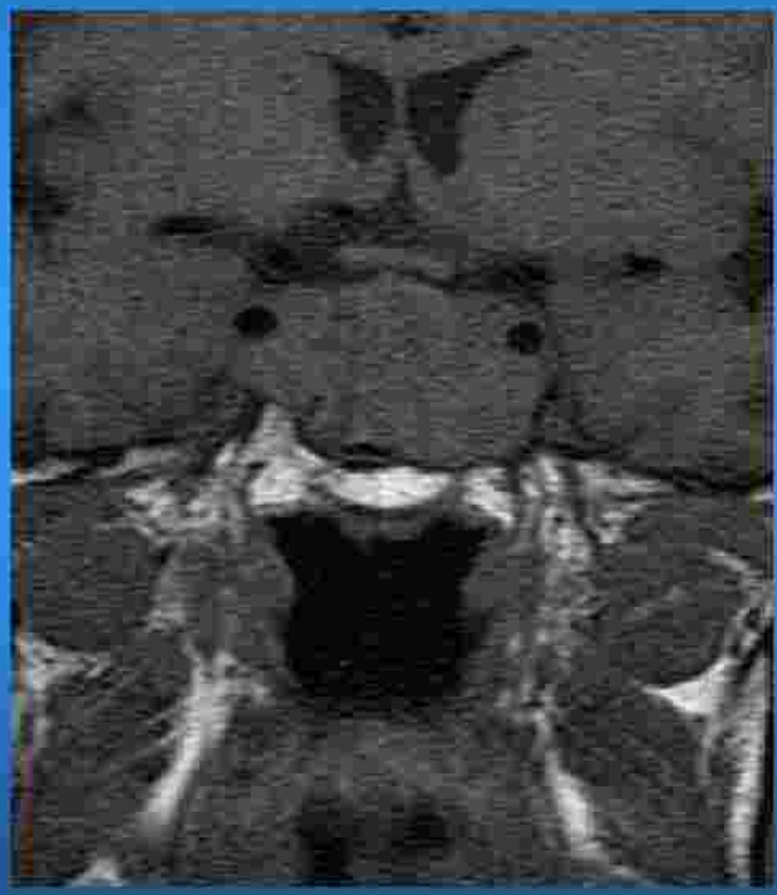
- Largest series of 884 patients with acromegaly treated with RT
- Mean GH levels declined from 13.5 ng/ml to
  - 5.3 ng/ml at 2 years
  - 2 ng/ml at 10 years
  - 1.1 ng/ml at 20 years
- 63% of patients achieved IGF-1 levels by 10 years

Jenkins JCEM 2006 (in press)

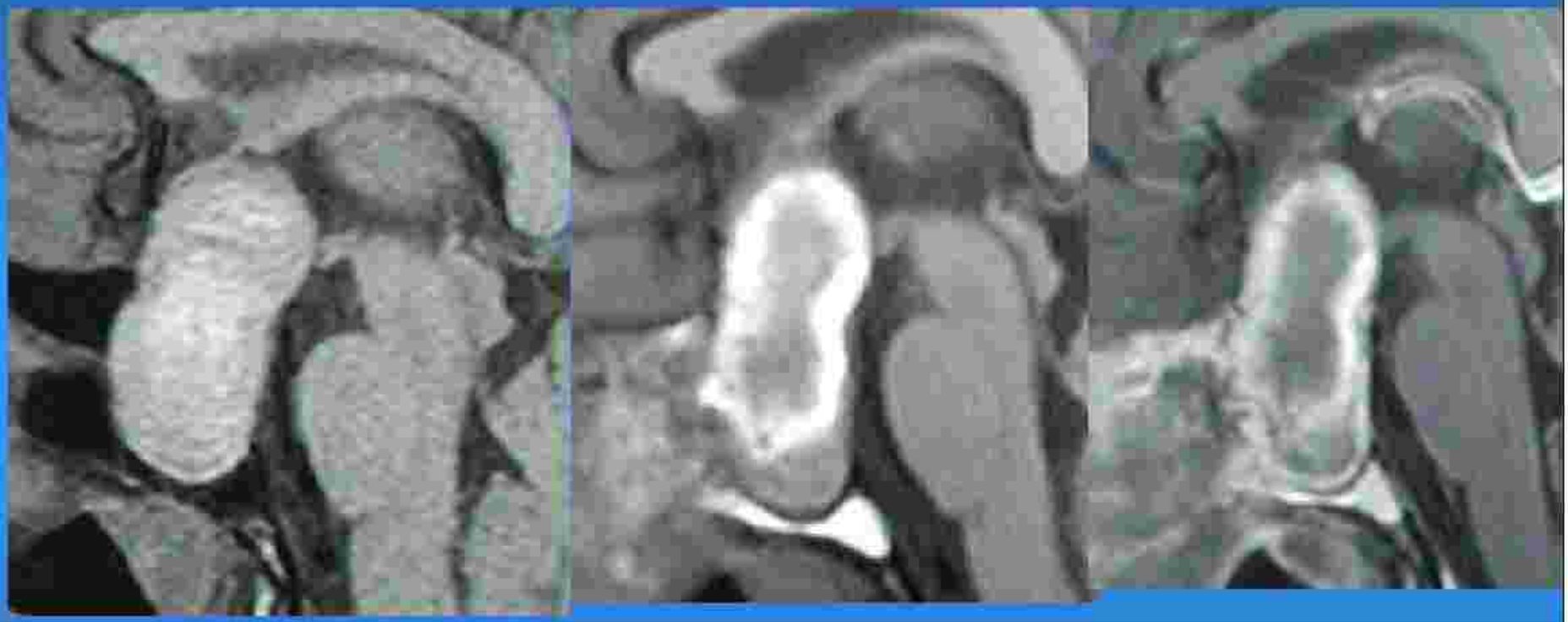
Pituitary adenoma

Cavernous sinus involvement



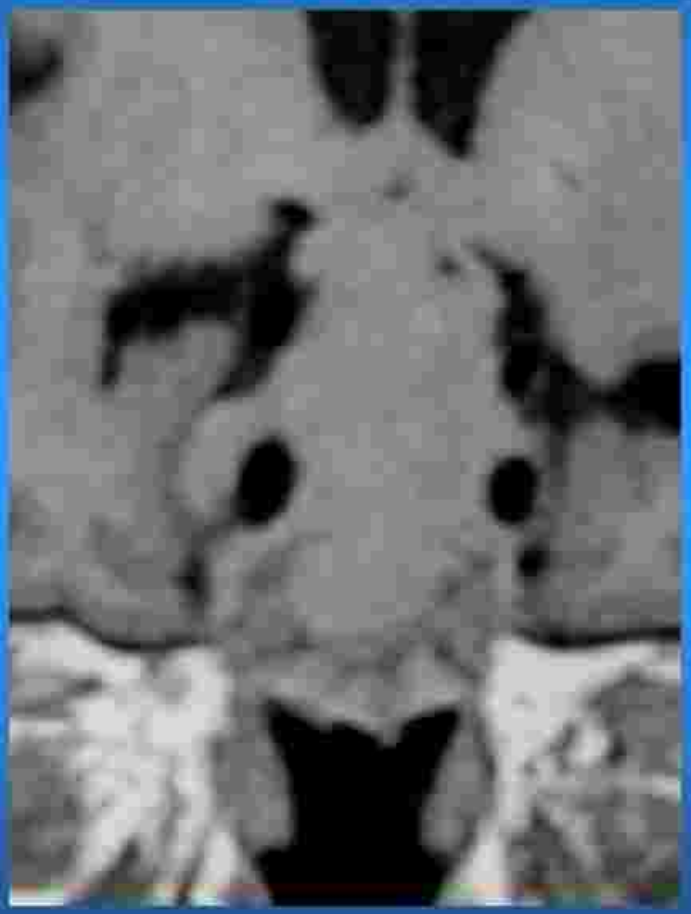


Immediate post op scan

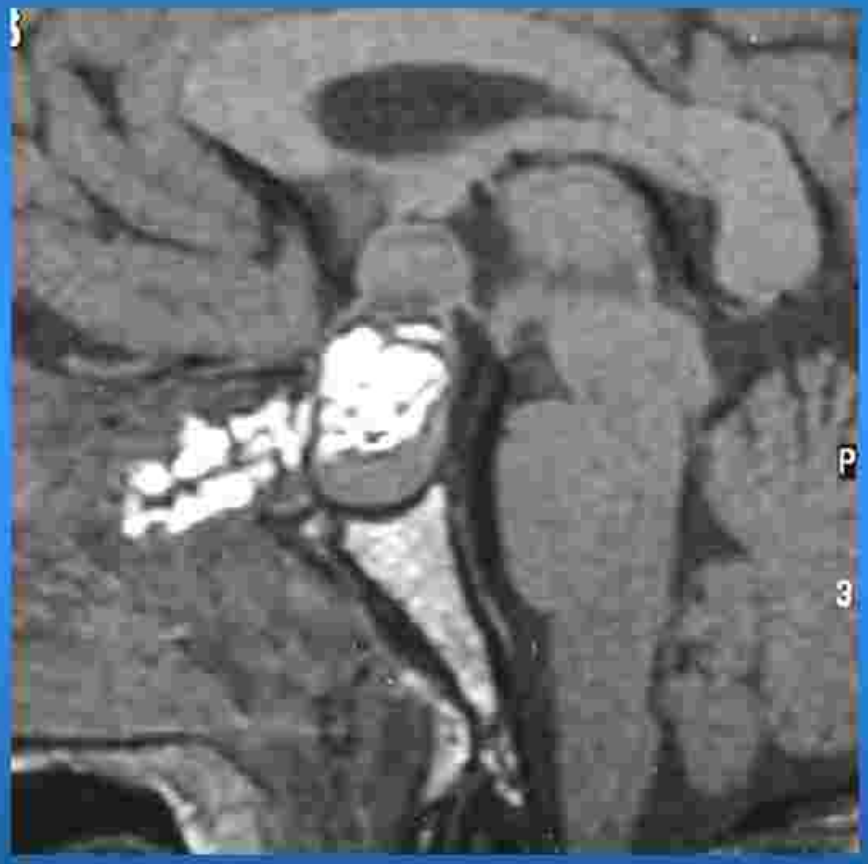


Erich Steiner et al. Radiology 1992
Teng et al – AJNR 1988

Packing material / post operative changes



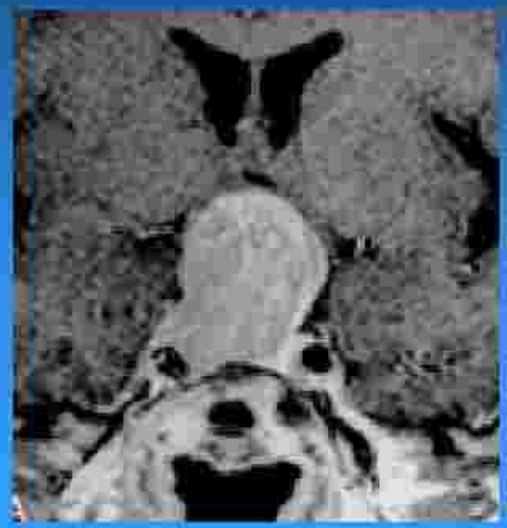
2 Mar 04



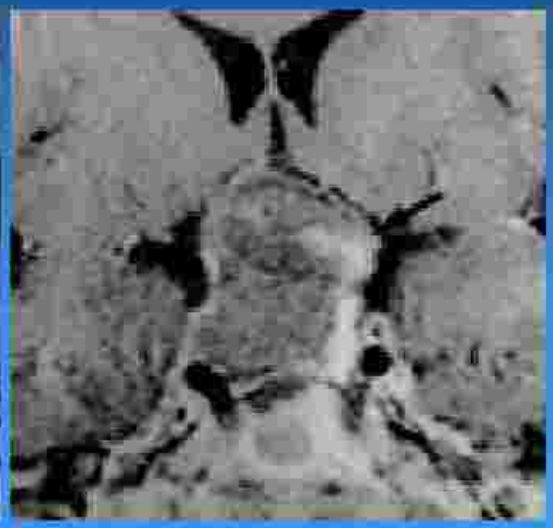
4 Mar 04

Evolution

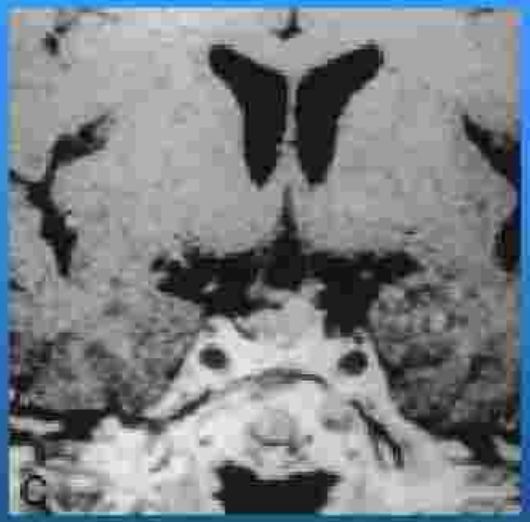
Pre-op



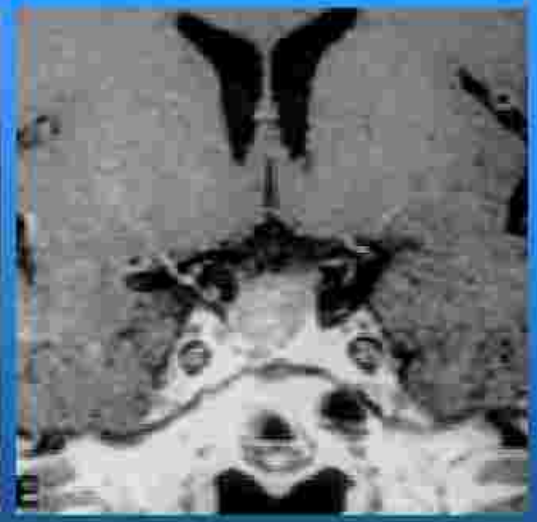
Day 2



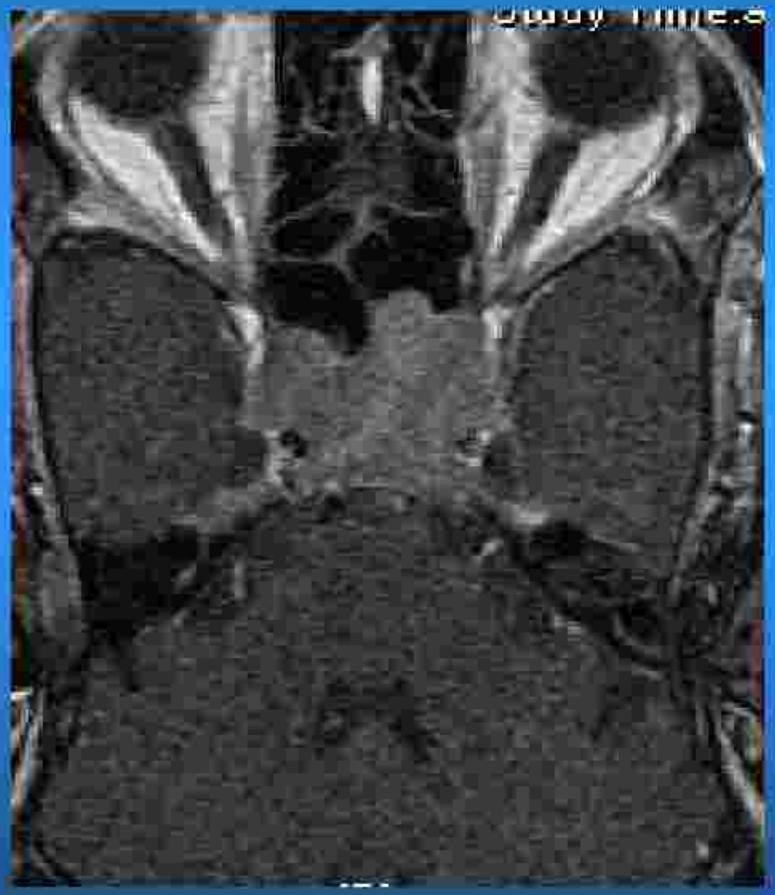
6 mths

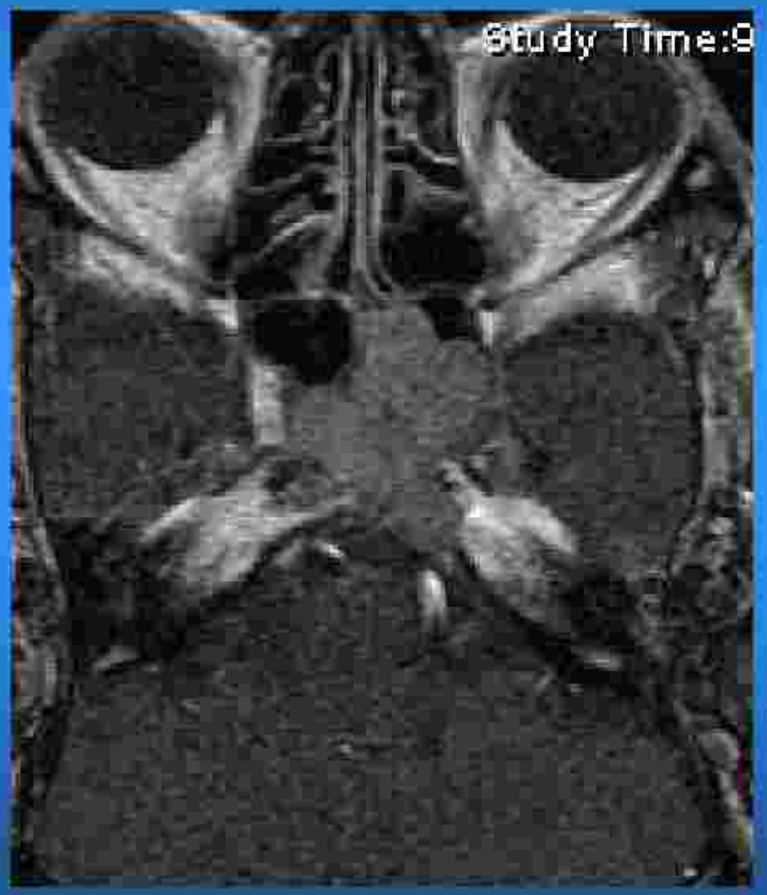


24 mths



Sphenoid/Inferior extent uncommon but can happen

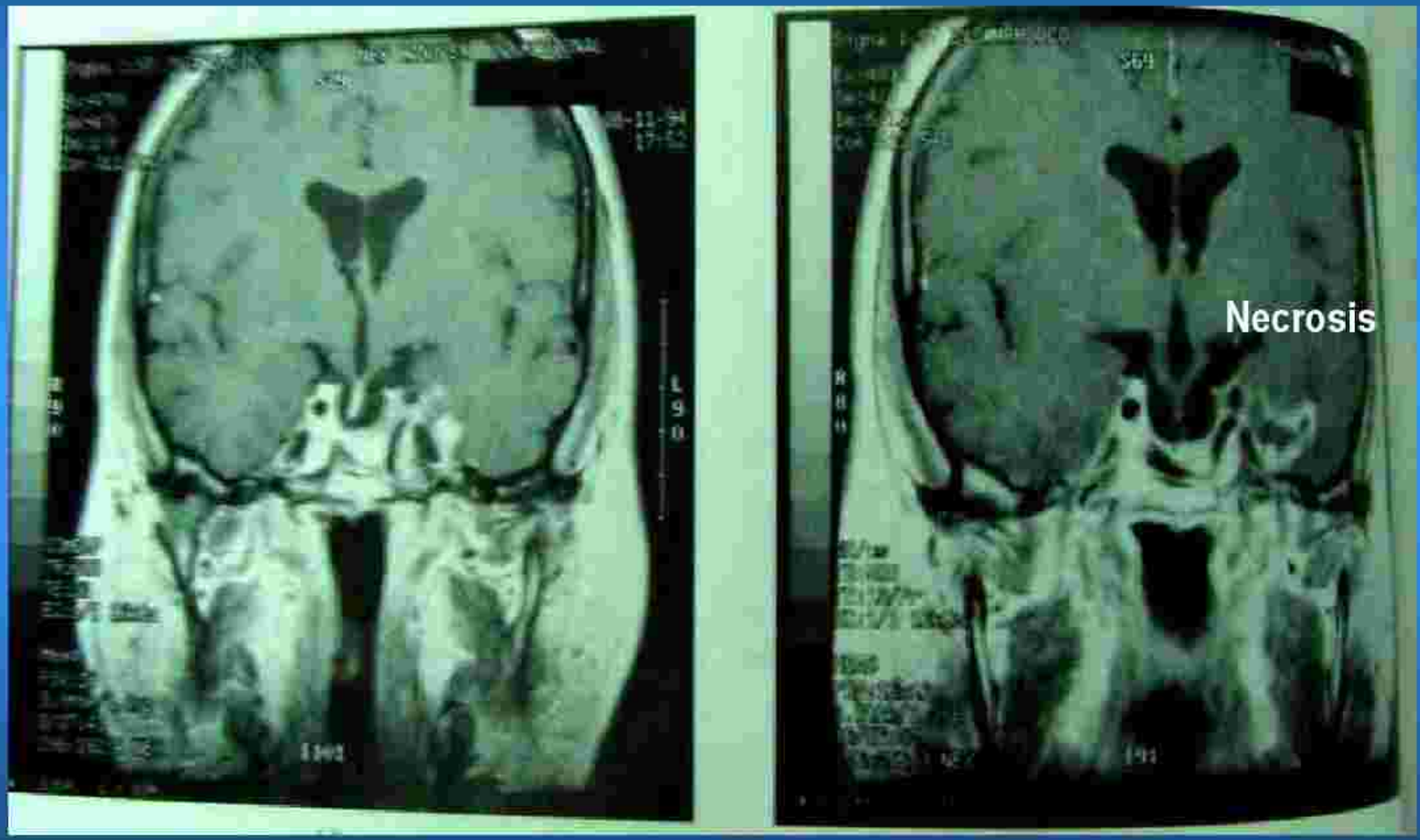




Late effects

- Hypopituitarism
- Optic Neuropathy
- Neurocognitive dysfunction
- Cerebrovascular Accidents
- Second Tumours

SRS



Misumori IJROBP 1998;42:431-6

Stereotactic Conformal Radiotherapy

Individualised planning

High Quality Assurance

Precise treatment delivery

French SRT data

110 consecutive patients treated with SRT to 50.4 Gy

75 with persistent macroscopic tumor, 47 with persistent hormonal secretions

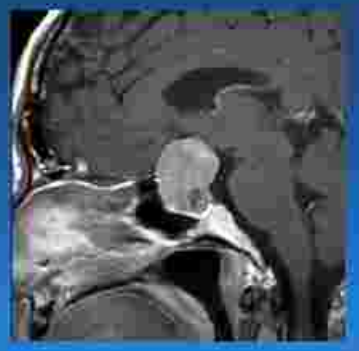
Treated At minimum FU of 48 months, only 1 patient progressed (**109/110 controlled/stable**)

Of functioning adenomas, 42% had complete response and 100% had objective response

Probability of requiring hormonal replacement at 4 and 8 years
28.5% and 35%

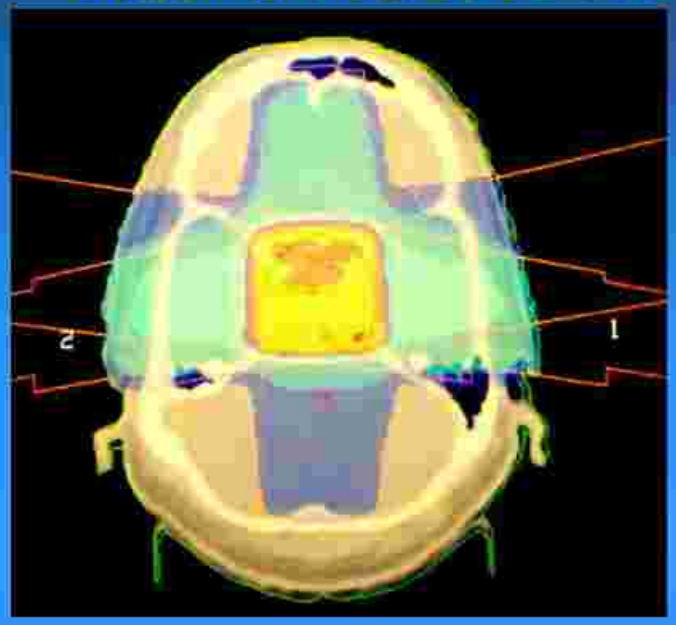
No other late sequelae

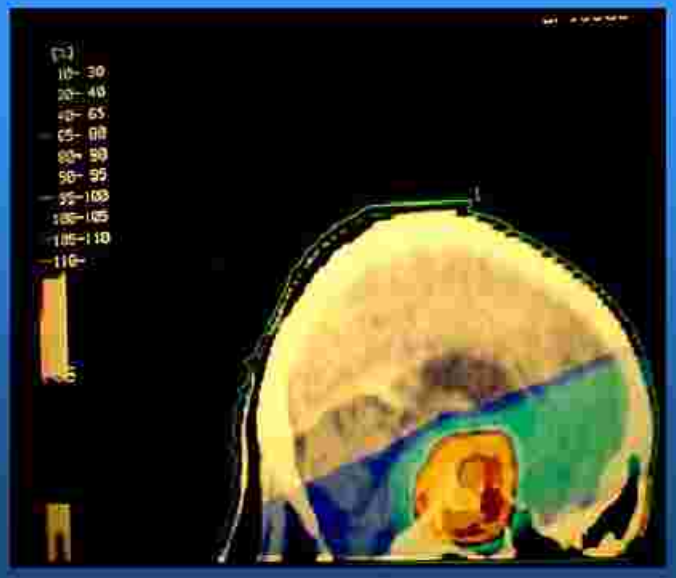
TMH audit of 3D CRT in pituitary adenomas



- Started in 2000
- 62 patients (48 non functioning and 14 secretory)
- Carefully implemented protocol
- GTV: residual disease on planning scan
- CTV: 5mm margin, edited appropriately
- PTV: 5 mm margin three dimensionally as per departmental study of assessment of random and systematic errors

Seller tumours: 3DCRT with 3-4 field conformal non-coplanar



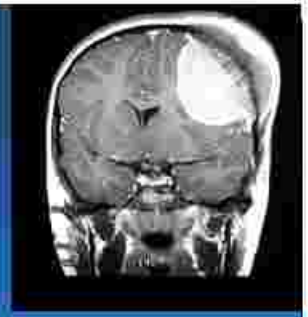


Gantry	Table
100	10
260	350
20-50	90

Results of 3DCRT

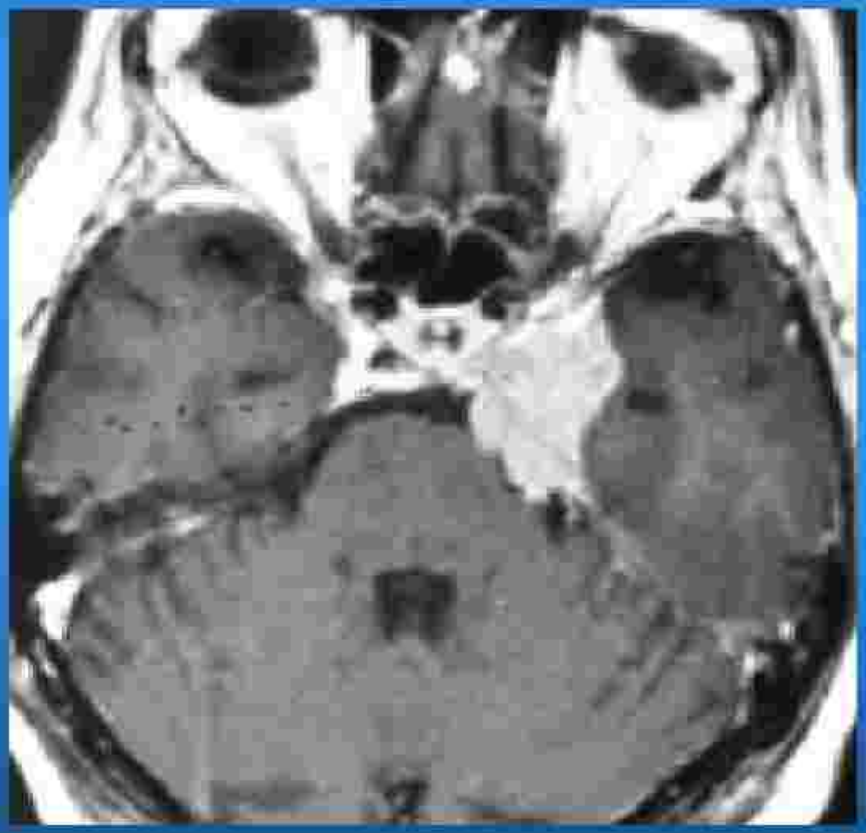
- 34 females and 28 males
- Median follow up = 28 months (12 months to 62 months)
- All 62 patients had radiologically verified tumour control (3 year actuarial PFS 100%)
- Vision stable/improved in all patients
- 1 patient developed second tumour

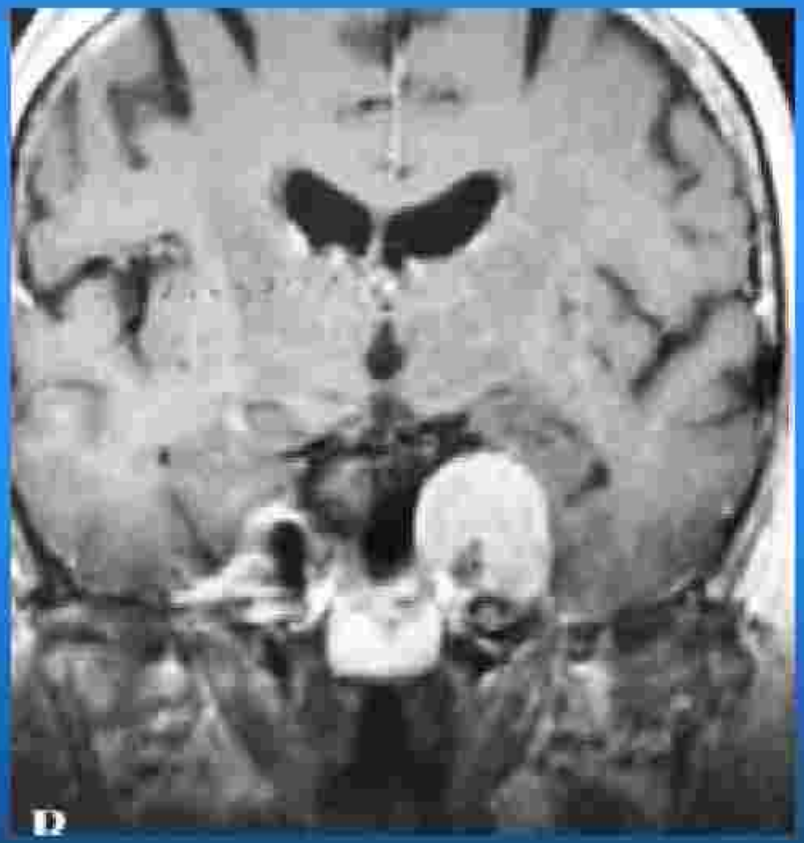
Meningioma



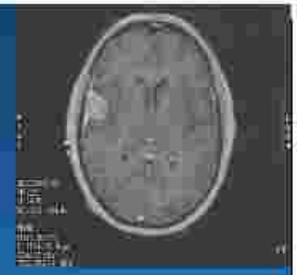
MRI (post Gadolinium) - MUST

Dural tail sign





Gross Total Resection: High Late Relapse

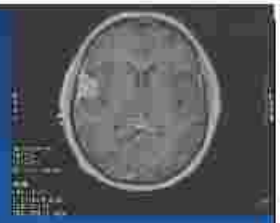


Author	Local Recurrence		
	5-yr	10-yr	15-yr
Mirimanoff (MGH)	7%	20%	32%
Condra (U Fl)	7%	20%	24%
Stafford (Mayo)	12%	25%	-

May sometimes cause significant morbidity in certain sites

Mirimanoff, Neurosurg 62:18, 1985
Condra, IJROBP 39:427, 1997
Stafford, Mayo Clin Proc 73:936, 1998

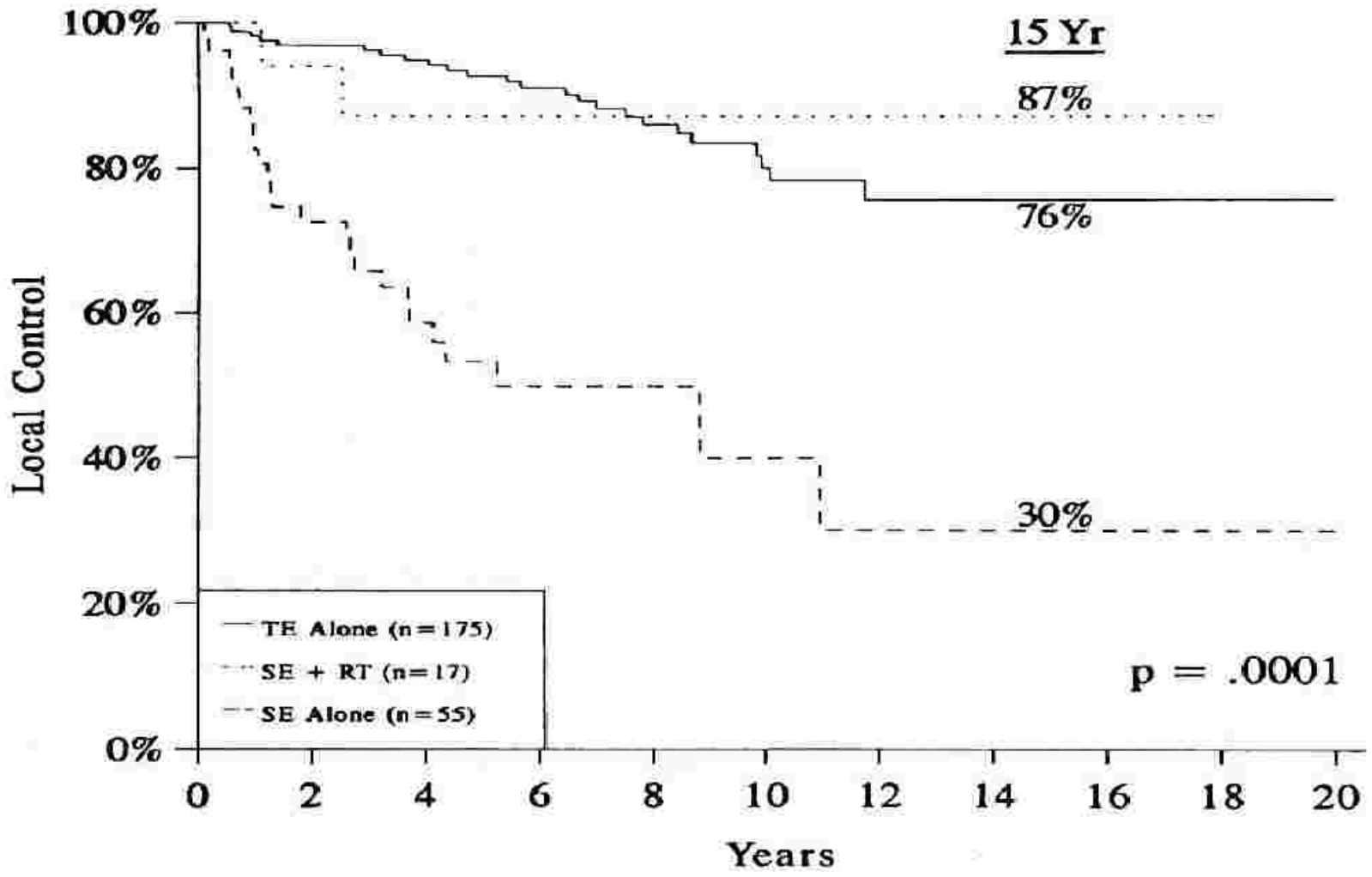
Subtotal Resection



Author	Local Recurrence			
	5-yr	10-yr	15-yr	20-yr
Wara (UCSF)	47%	63%	-	75%
Condra (U Fl)	47%	60%	70%	-
Stafford (Mayo)	39%	61%	-	-

Wara, Am J Reontgenol Ther Nucl Med 123:453, 1975
Stafford, Mayo Clin Proc 73:936, 1998
Condra, IJROBP 39:427, 1997

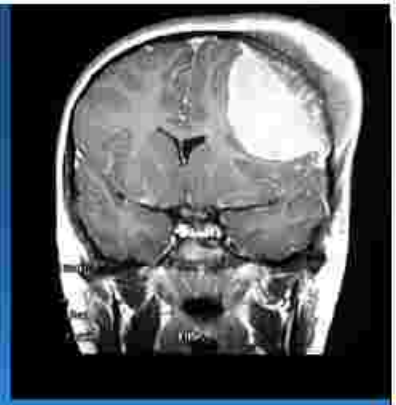
Adjuvant Radiotherapy



5 Yr Actuarial PFS

Author (year)	n	GTR	STR	STR+ RT
Mirimanoff (1985)	225	93% (n=145)	63% (n=80)	
Taylor (1988)	132	96% (n=90)	43% (n=42)	85% (n=13)
Glaholm (1990)	117			84%
Miralbell (1992)	115		48% (n=79)	88% (n=17, 8yPFS)
Mahmood (1994)	254	98% (n=183)	54% (n=65)	4/6 stable disease
Goldsmith (1994)	117			89% (98% p1980, n=77)
Condra (1997)	246[a]	95% (n=174)	83% (n=55)	86% (n=17, 5 atypical)
Stafford (1998)	581	88% (n=465)[b]	61% (n=116)[c]	
Nutting (1999)	82			92%
Vendrely (1999)	156			89% (12 >WHO grade 1)
Dufour (2001)	31			93%
	2236	88-98%	43-83%	84-98%

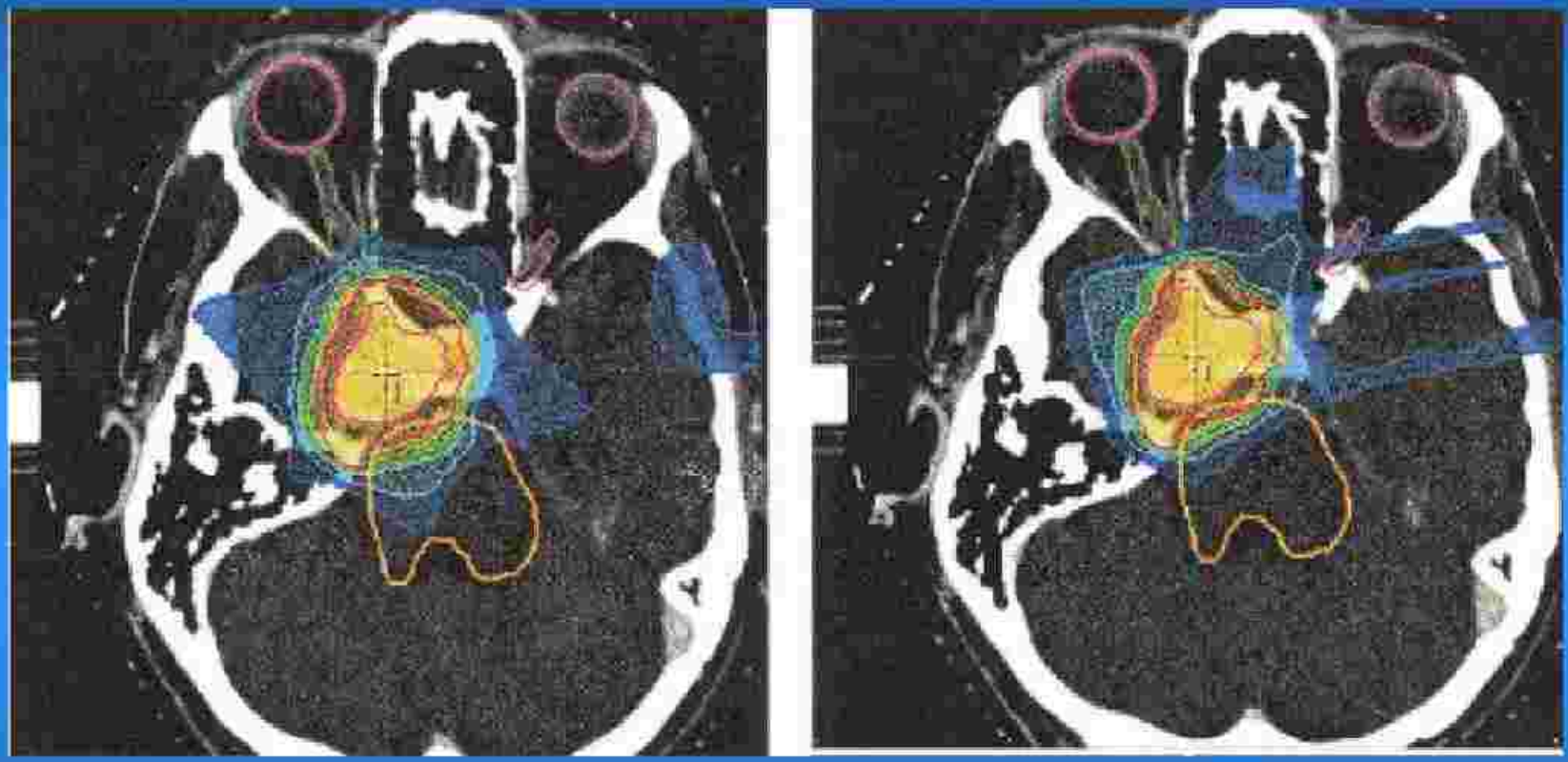
Anaplastic/Malignant Meningioma



	PFS 2yrs	PFS 5yrs
Subtotal resection	44%	0%
STR + XRT	87%	0%
Total resection	70%	28%
TR + XRT	100%	57%

Dziuk J. NeuroOnc 37: 177, 1998

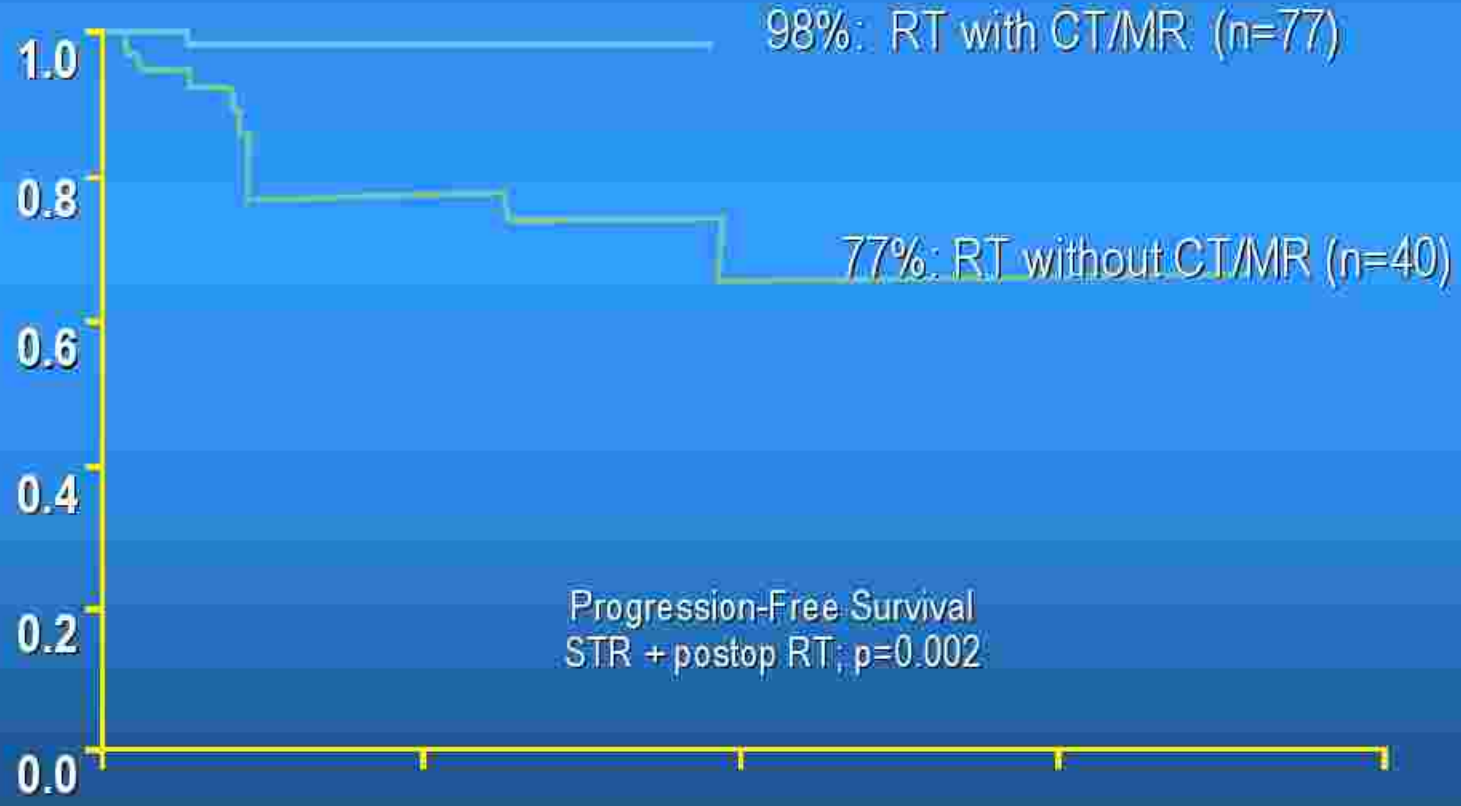
Meningiomas – Conformal RT



SCRT IMRT

- Sharply delineated, Not infiltrating the brain, Complex shapes
- Often Adjacent to eloquent structures, 54 to 60 Gy required

Impact of modern RT planning



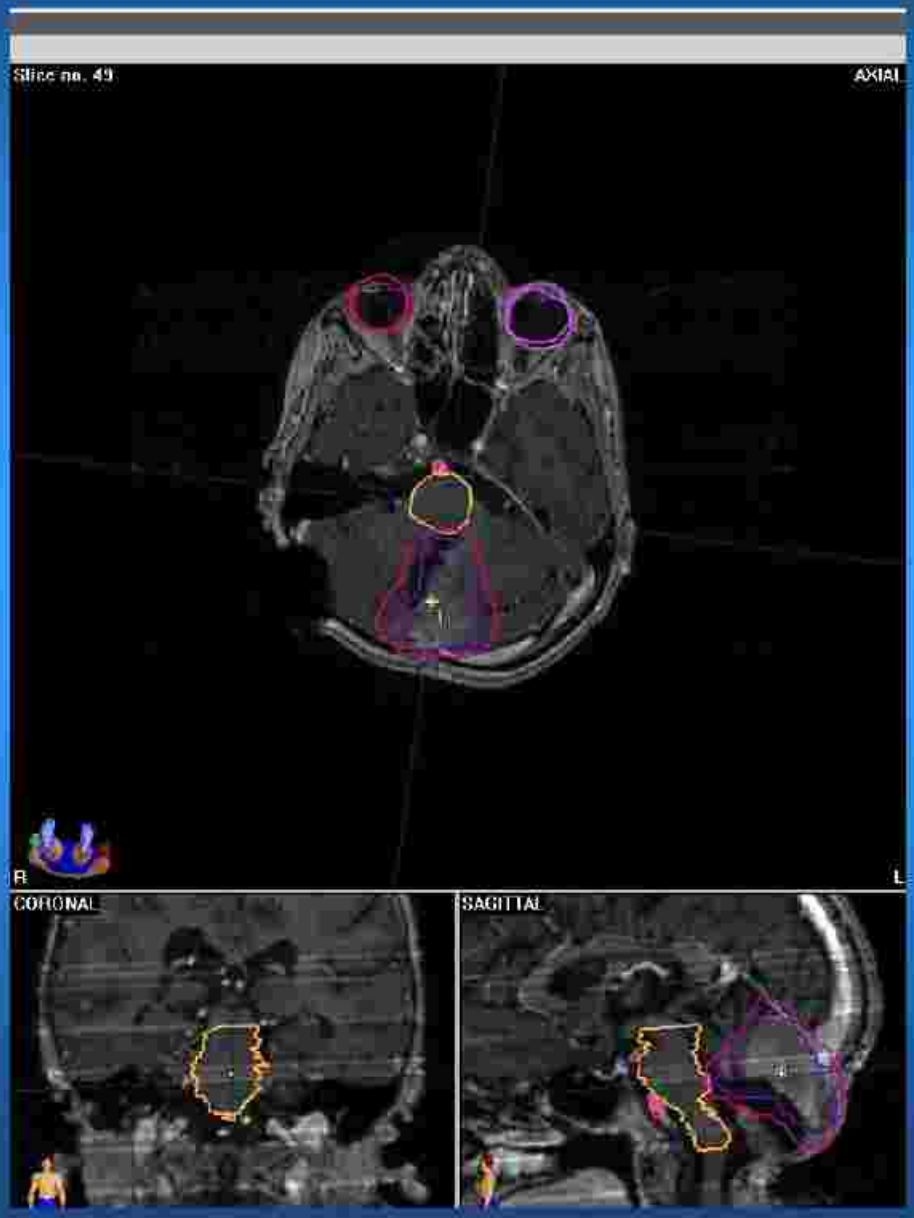
Goldsmith J Neurosurg 80:195-201, 1994

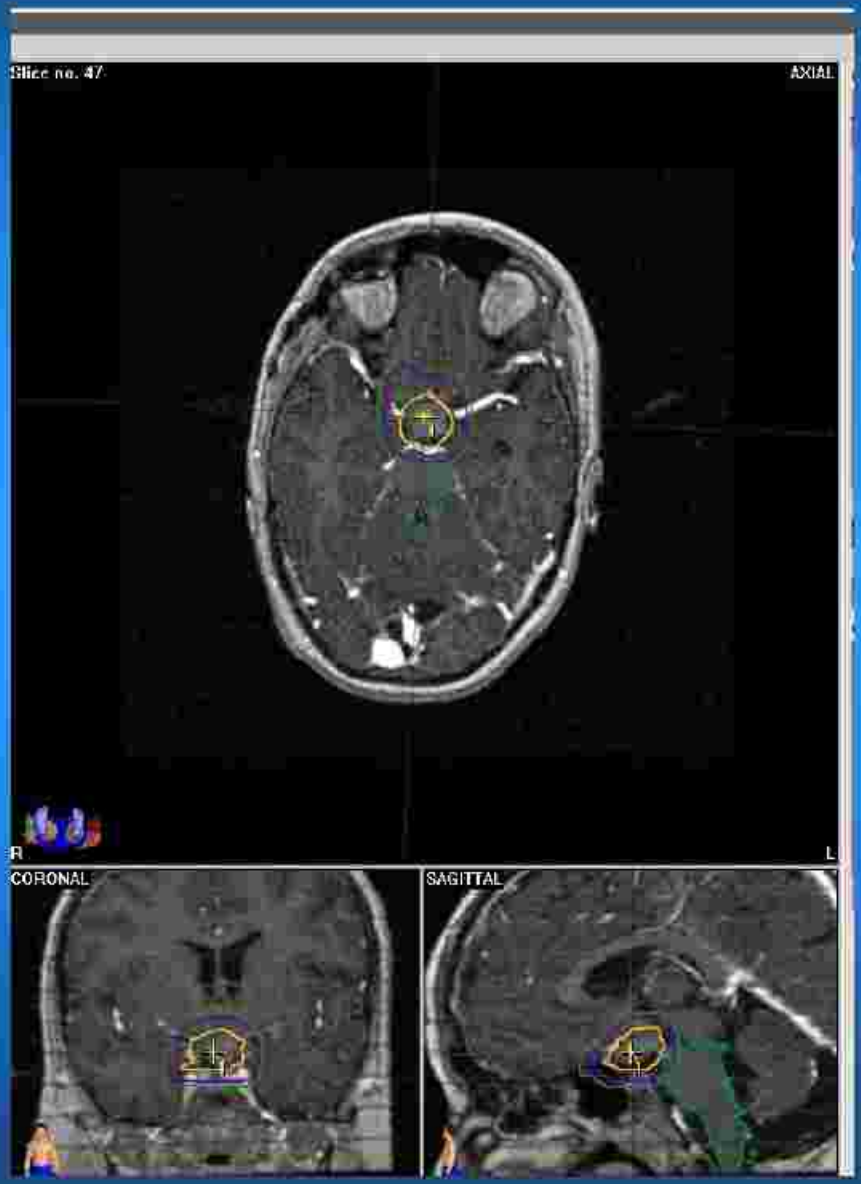
Fractionated Stereotactic/conformal radiotherapy

- Indicated for residual tumours
- Also for tumours close to critical structures such as optic apparatus/brain stem (optic sheath meningioma)
- 80-100% local control and PFS
- Less doses to the normal brain than conventional radiotherapy and so less toxicity
- Emerging impressive "prospective" data of maintained cognitive and neuropsychological function (*Steinworth Radioth & Oncol 2003;69:177-82*)

Debus IJROBP 2001
Jalali Clin Oncol 2002;14:103-9
Selch IJROBP 2004;59:101-11

Brain stem + spinal cord

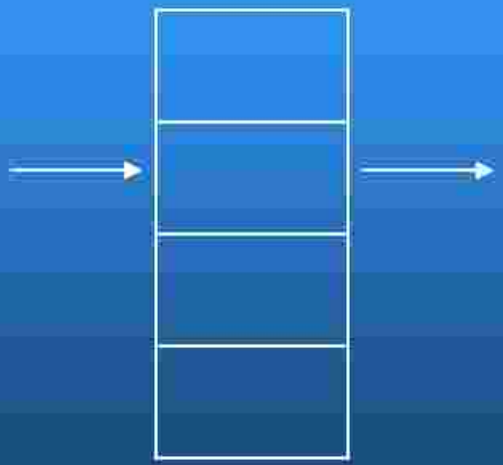




NTCP organ models

Serial model (e.g spinal cord, cranial nerves)

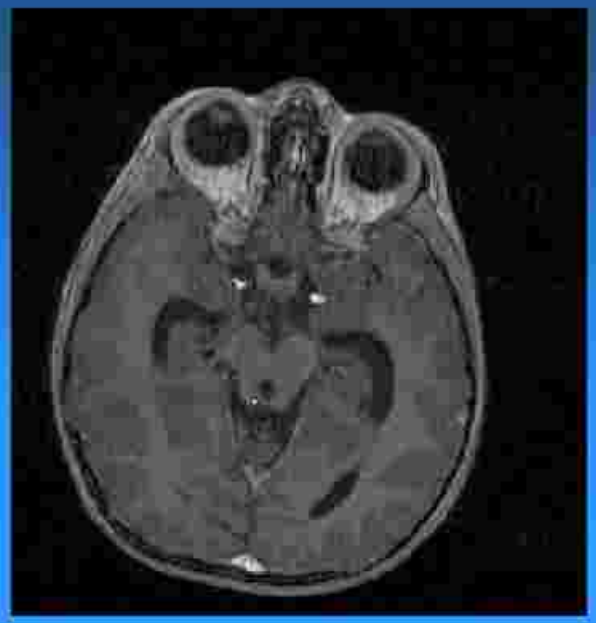
Any break causes complication,
volume effect less important

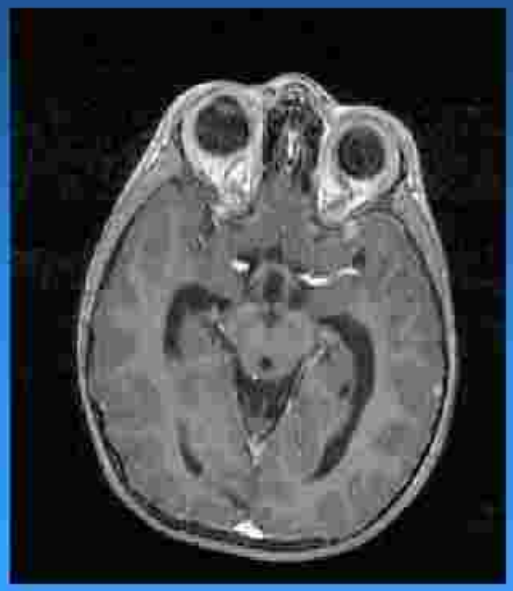


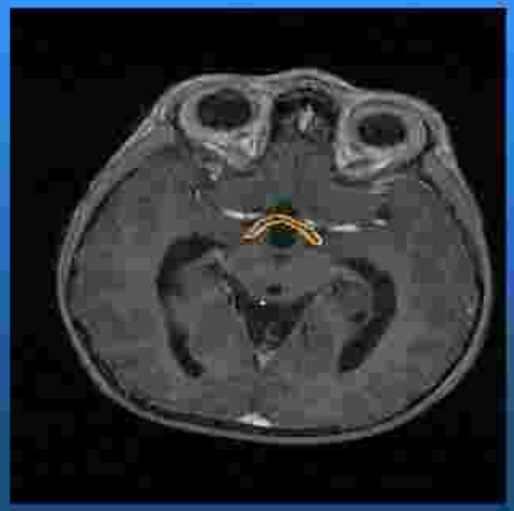
Parallel Model (e.g pituitary hypothalmic axis)

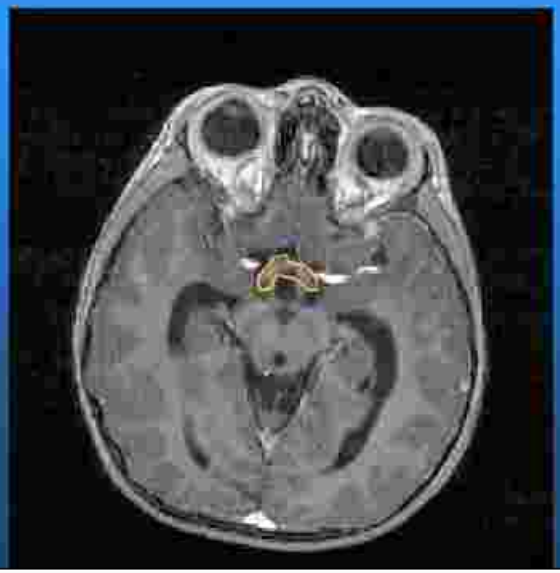
Damaging a few - intact organ function, volume effect present

Optic chiasm

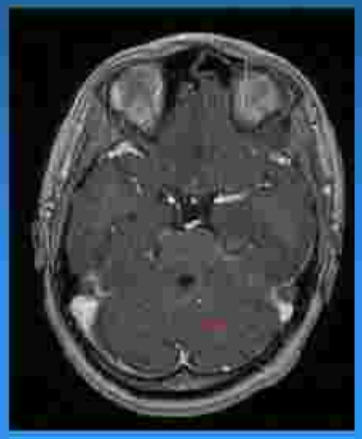
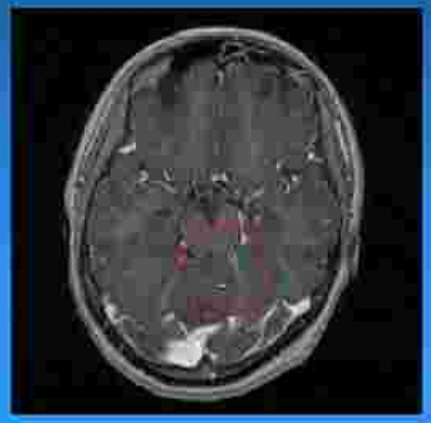
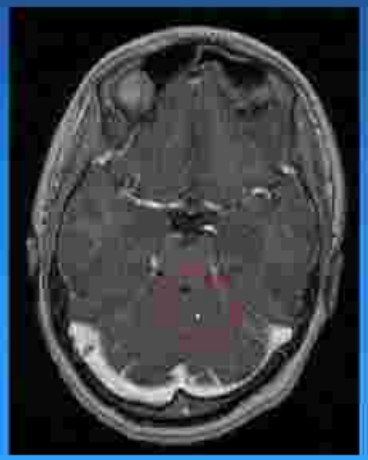
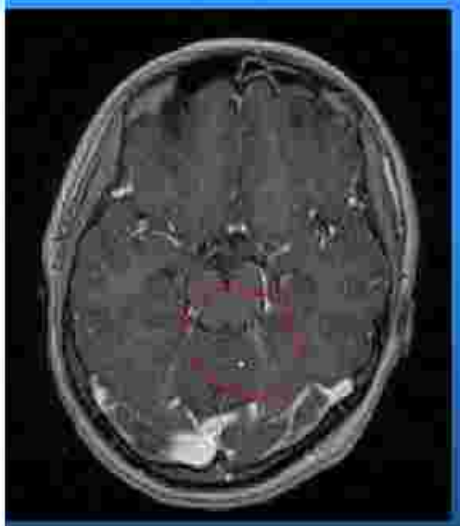
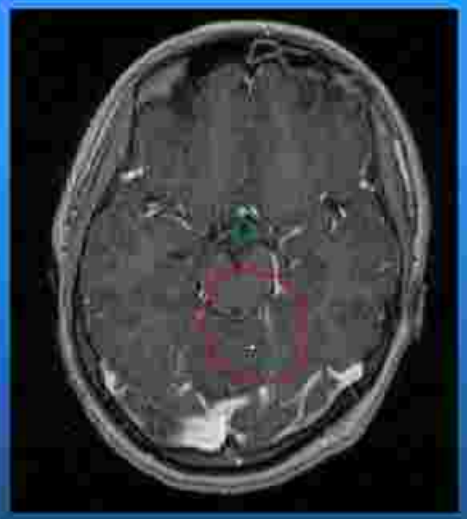
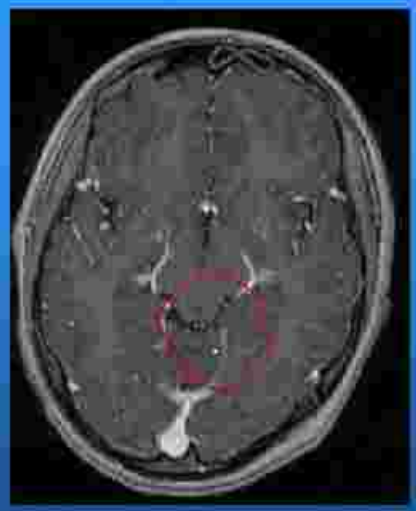
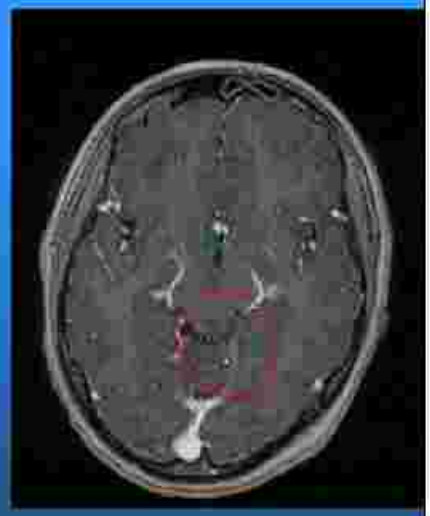








Hypothalamus (PHA)

CTV generation

- Tumour histology; benign Vs low-grade Vs malignant
- Patterns of failure
- Resolution of neuro-imaging
- Confidence to delineate GTV accurately
- Any known anatomical barrier such as falx, tentorium, bone and base of skull
- Well studied and carefully implemented uniform margin generation protocol