

Radiotherapy in the management of benign and malignant primary brain tumours

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**technical aspects of
cranial RT**

**RT & SRT in benign
brain tumours**

**RT & SRT in malignant
brain tumours**

outcome of SRT

Radiotherapy for primary brain tumours

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outcome of SRT

Radiotherapy for primary brain tumours

Attributes of modern local RT delivery

refinements of conformal radiotherapy



precision

conformality

photons

protons

time factor (4D RT)

intrafraction patient and tumour motion

interfraction changes in tumour & normal tissue

quality assurance

imaging closer to treatment delivery (**IGRT**)

Radiotherapy technologies

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refinements of conformal radiotherapy



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accurate tumour localisation

precise dose targeting

immobilisation

image guidance

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Radiotherapy technologies

Imaging in the radiotherapy process

Challenges to accuracy of target delineation

operator dependent

technical

visualisation	coregistration
interpretation	distortion

Radiotherapy for brain tumours

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Radiotherapy for brain tumours

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visualisation

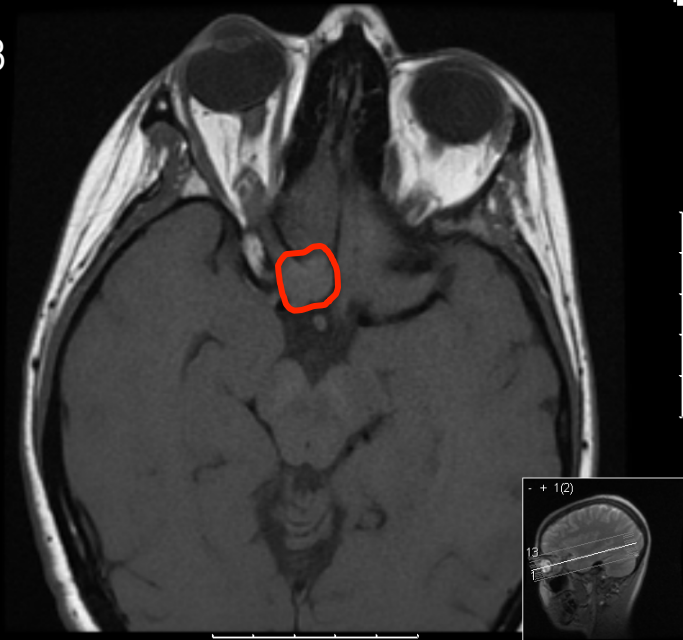
coregistration

interpretation

distortion

Radiotherapy for brain tumours

12.8.08



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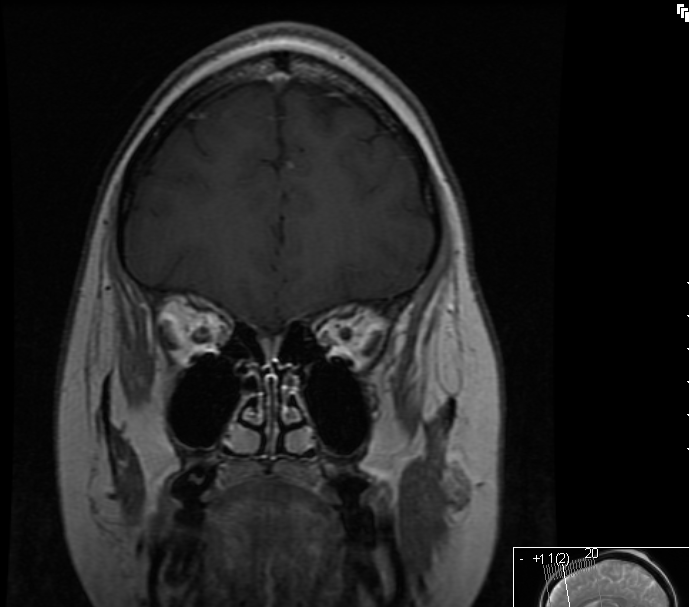


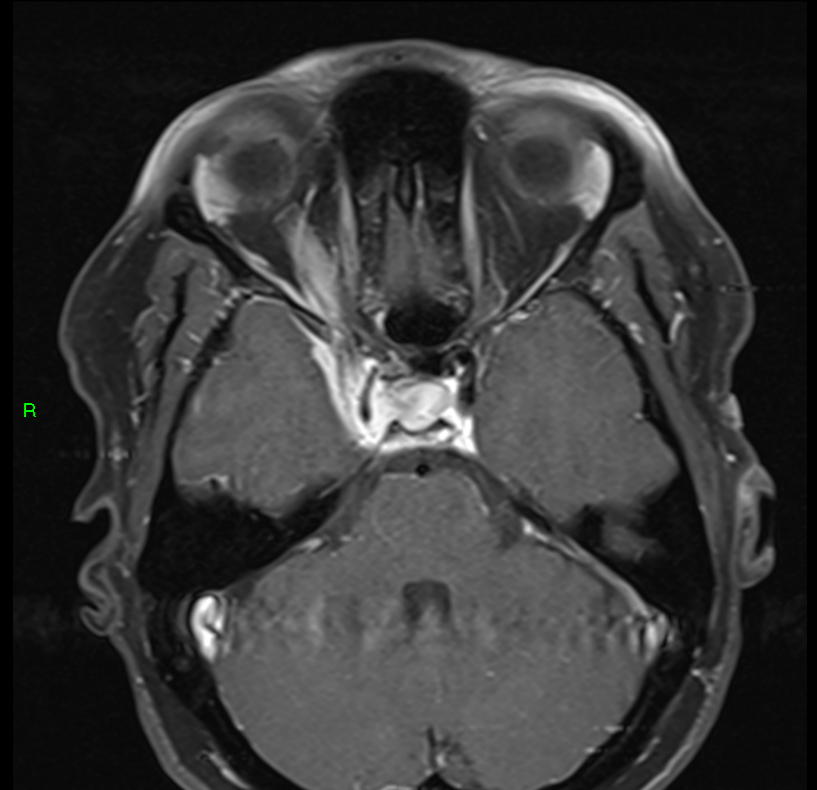
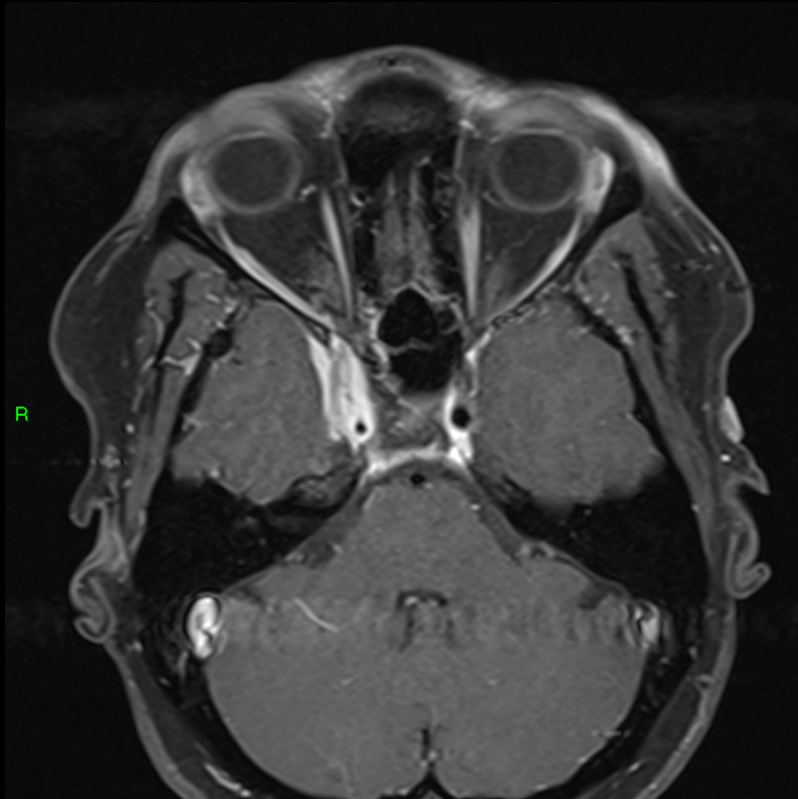
Figure 1 is a coronal T1-weighted MRI scan of the head. A white arrow points to a hyperintense lesion in the right frontal lobe. An inset in the bottom right corner shows a sagittal view with a line indicating the slice level at +12 cm.

Figure 1 shows an axial T1-weighted MRI scan of the brain. A white arrow points to a lesion in the posterior horn of the right lateral ventricle. An inset in the bottom right corner shows a sagittal view of the brain with a line indicating the level of the axial slice.

A coronal T1-weighted MRI scan of the brain. A white arrow points to a hyperintense (bright) lesion located in the right sphenoid sinus, which is situated posterior to the nasal cavity and inferior to the sella turcica. The surrounding bony structures and other sinuses appear normal.

A coronal T1-weighted MRI scan of the brain. A white arrow points to a hyperintense lesion located in the right sphenoid sinus, which is situated posterior to the nasal cavity and anterior to the sella turcica. The surrounding brain parenchyma and other sinuses appear normal. A small inset in the bottom right corner shows an axial view of the same region, with a line indicating the plane of the coronal slice.

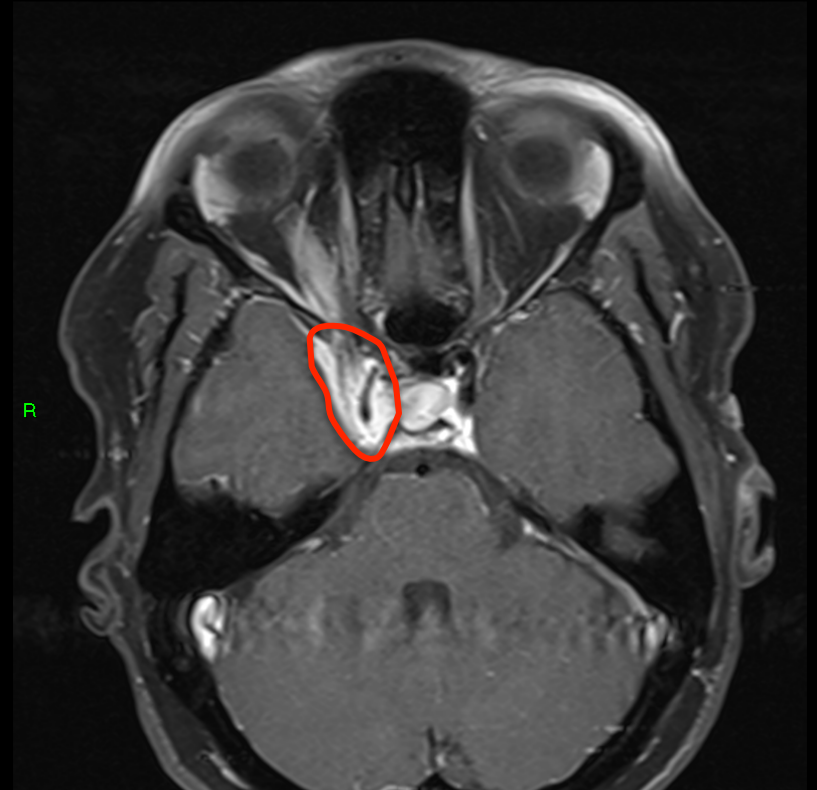
cavernous meningioma



cavernous meningioma

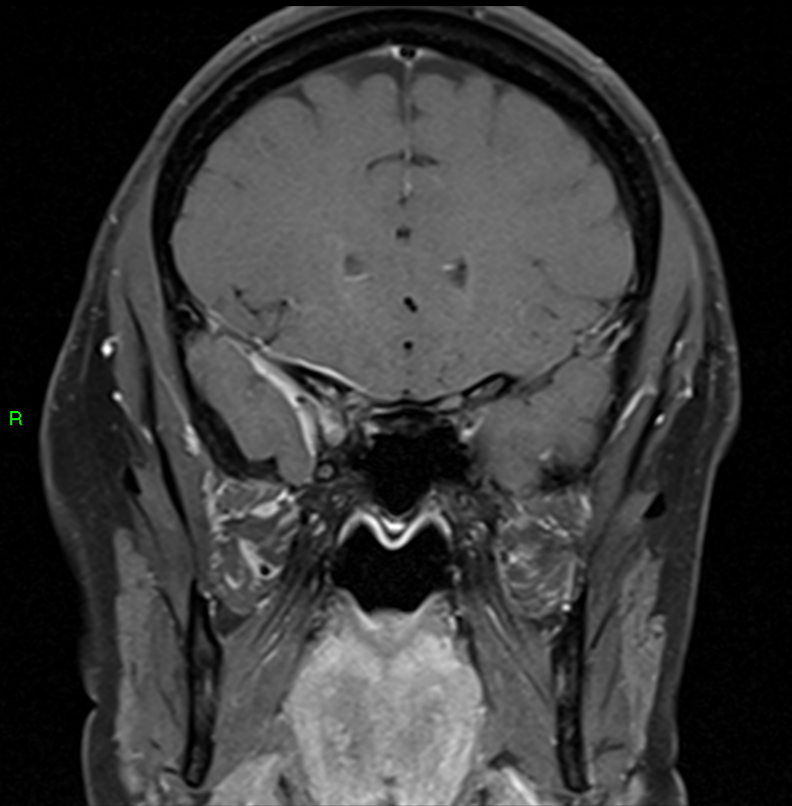


P

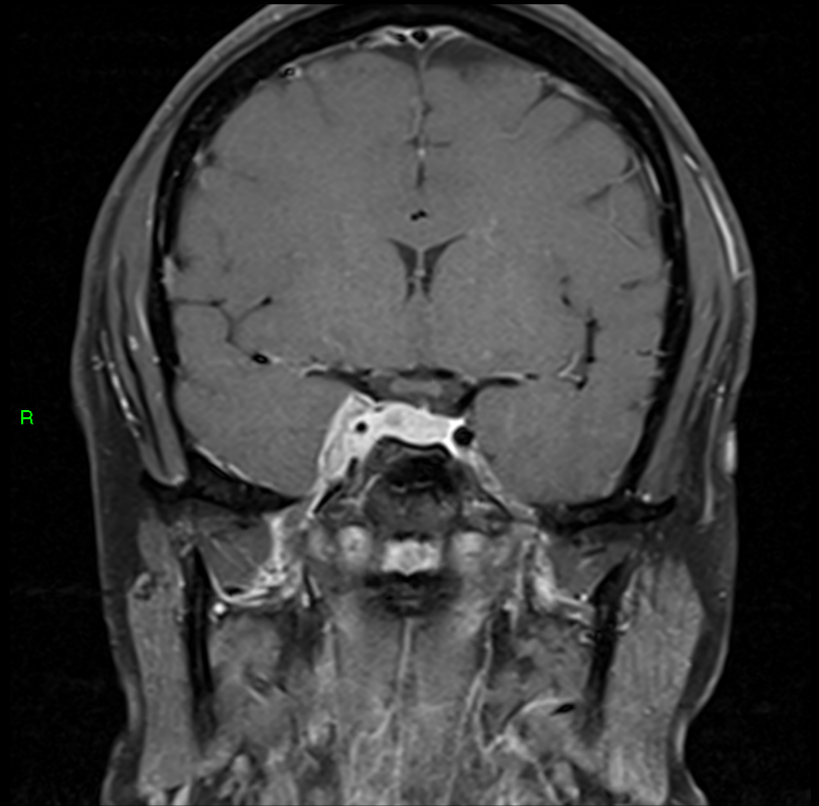


P

cavernous meningioma



I



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cavernous meningioma



P



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Imaging in the radiotherapy process

Challenges to accuracy of target delineation

operator dependent

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visualisation

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Radiotherapy for brain tumours

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image guidance

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refinements of conformal radiotherapy



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localised target delivery
normal tissue avoidance

time factor (4D RT)

intrafraction patient and tumour motion

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Radiotherapy technologies

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refinements of conformal radiotherapy



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conformality

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protons

Delivery equipment

linac - conventional/adapted

small linac on robotic arm (Cyberknife)

helical rotating linac (Tomotherapy)

multiple beams from fixed unit (Gamma Knife)

Delivery techniques

multiple conformal x-ray fields

single or multiple dynamic arcs +/- IMRT

single or multiple isocentres

multiple sources & isocentres (GK)

multiple small beams & isocentres (CK)

Stereotactic

air motion

to & normal tissue

delivery (IGRT)

Radiotherapy technologies

Stereotactic radiotherapy

can only be carried out with
dedicated stereotactic equipment

is best achieved with IMRT or
VMAT

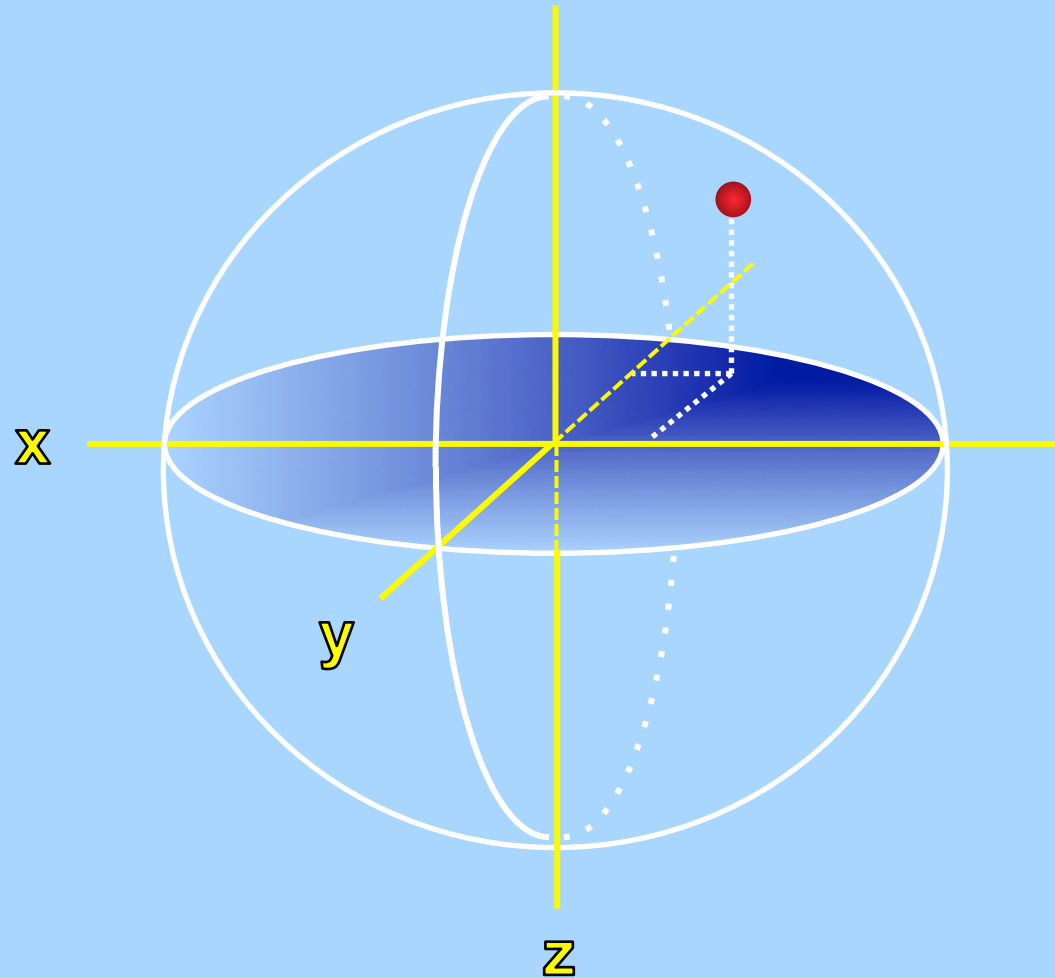
is a high precision conformal
radiotherapy

allows for GTV-PTV margin $< 1\text{mm}$

all of these


none of these

Stereotaxy



Classification of radiotherapy technologies

Stereotaxy



**“stereotactic radiotherapy”
is marketing terminology**

Classification of radiotherapy technologies

Stereotactic radiotherapy attributes

- Precision
- Conformality
- Dose
- Fractionation

High precision localised radiotherapy

Deconstructing stereotactic radiotherapy

Stereotaxy



**“stereotactic radiotherapy”
is a high precision localised radiotherapy**

Classification of radiotherapy technologies

Stereotactic radiotherapy

can only be carried out with
dedicated stereotactic equipment

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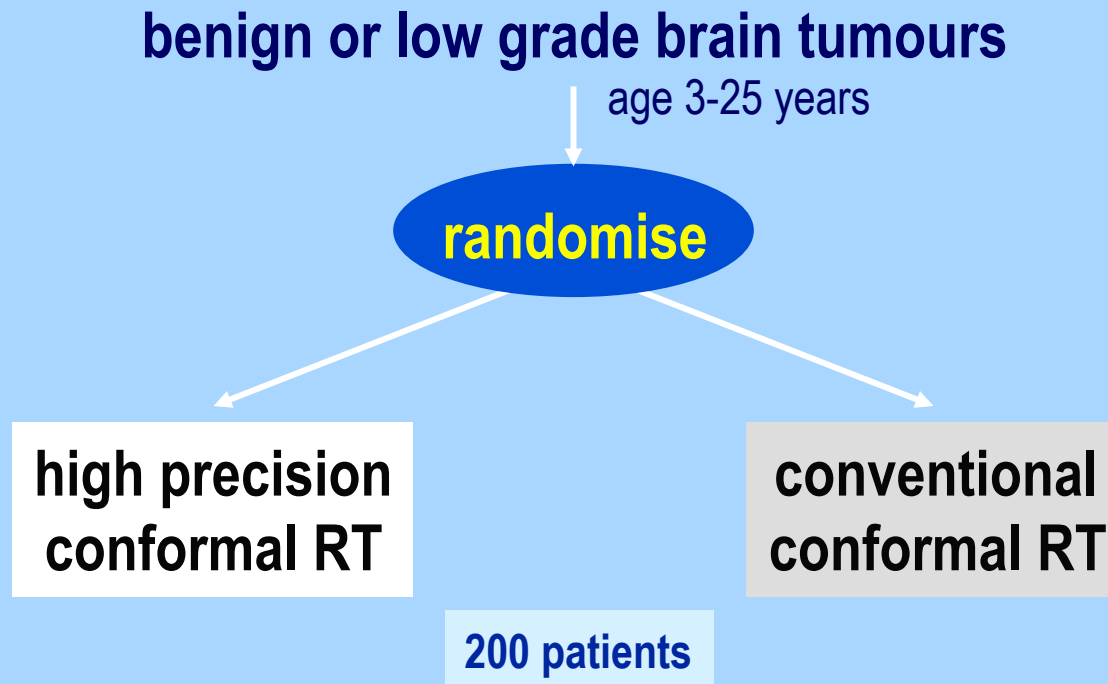
is a high precision conformal
radiotherapy

allows for GTV-PTV margin $< 1\text{mm}$

all of these

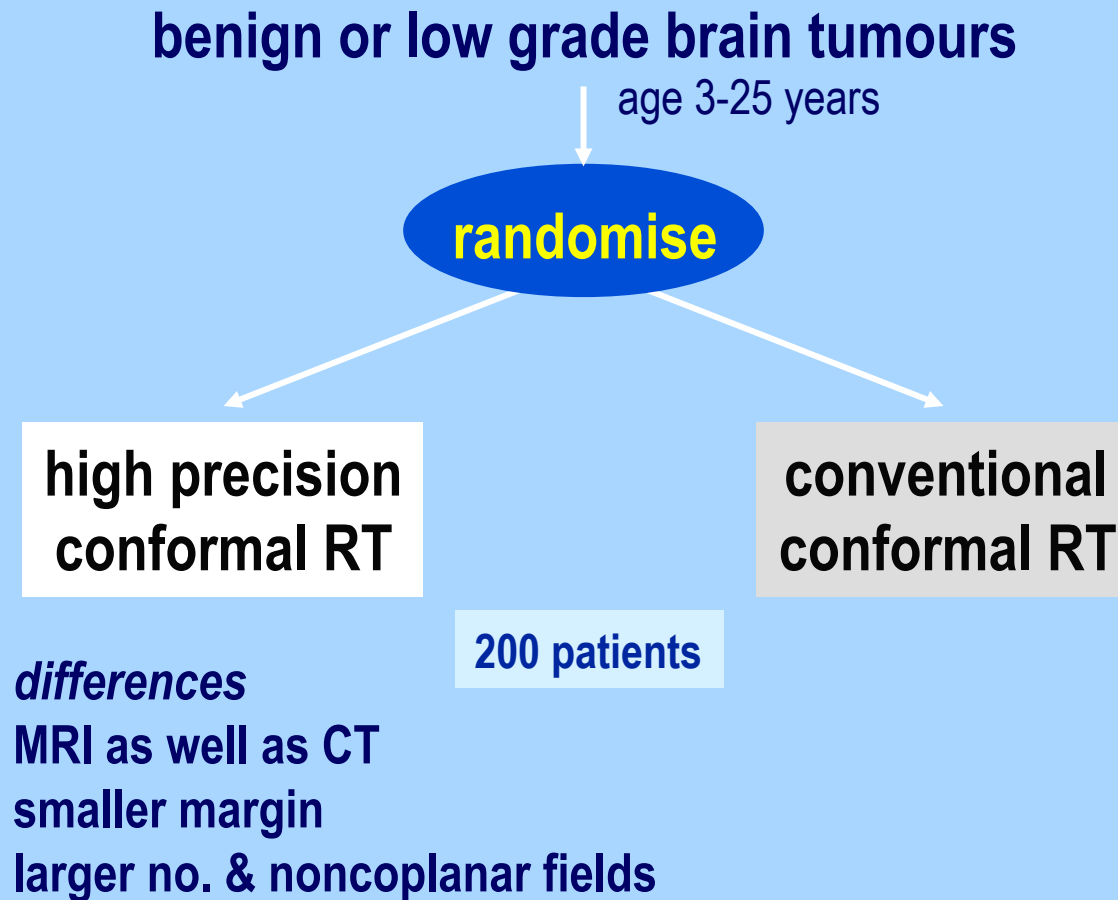
none of these

high precision vs conventional conformal RT



Benefit of high precision conformal radiotherapy

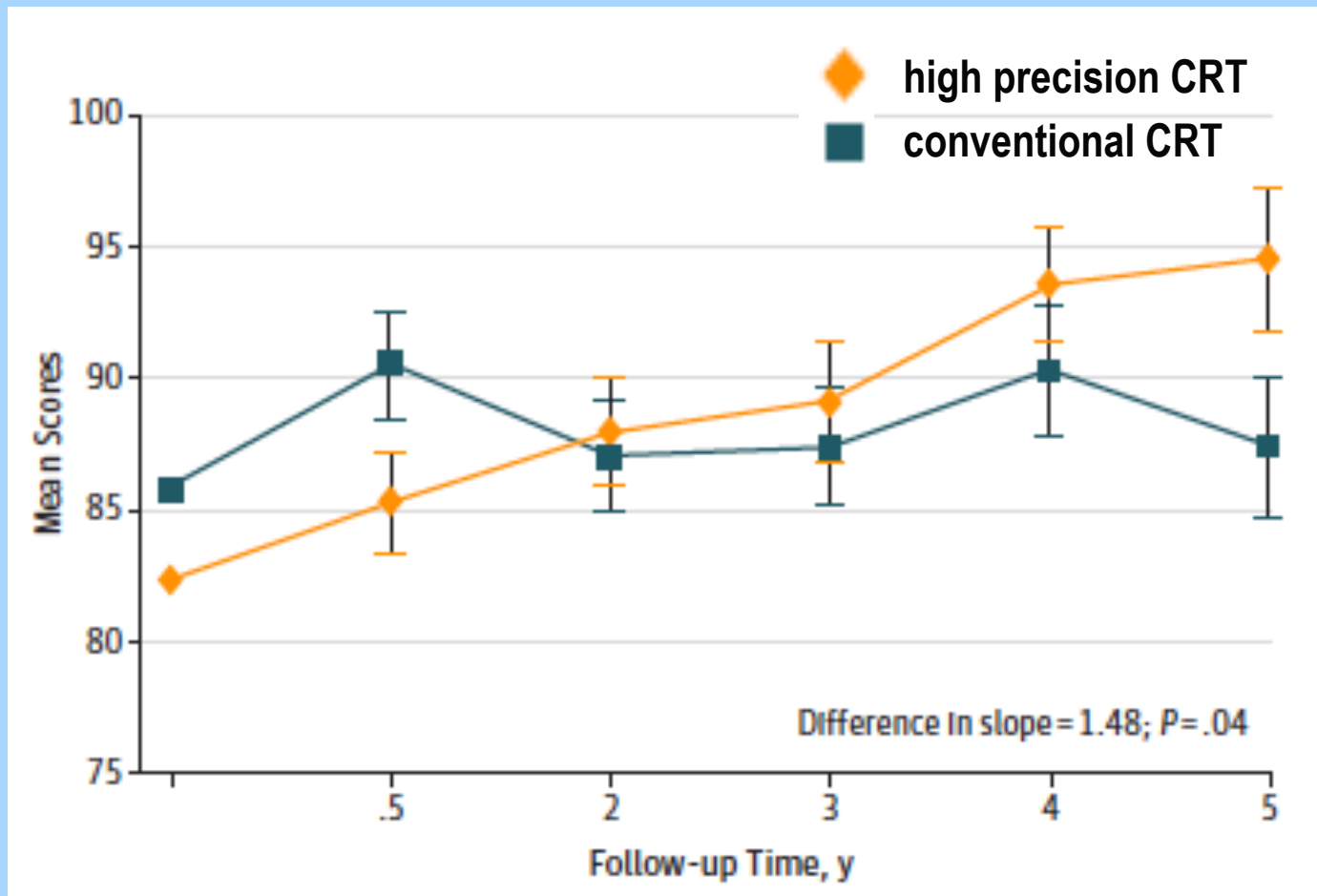
high precision vs conventional conformal RT



Benefit of high precision conformal radiotherapy

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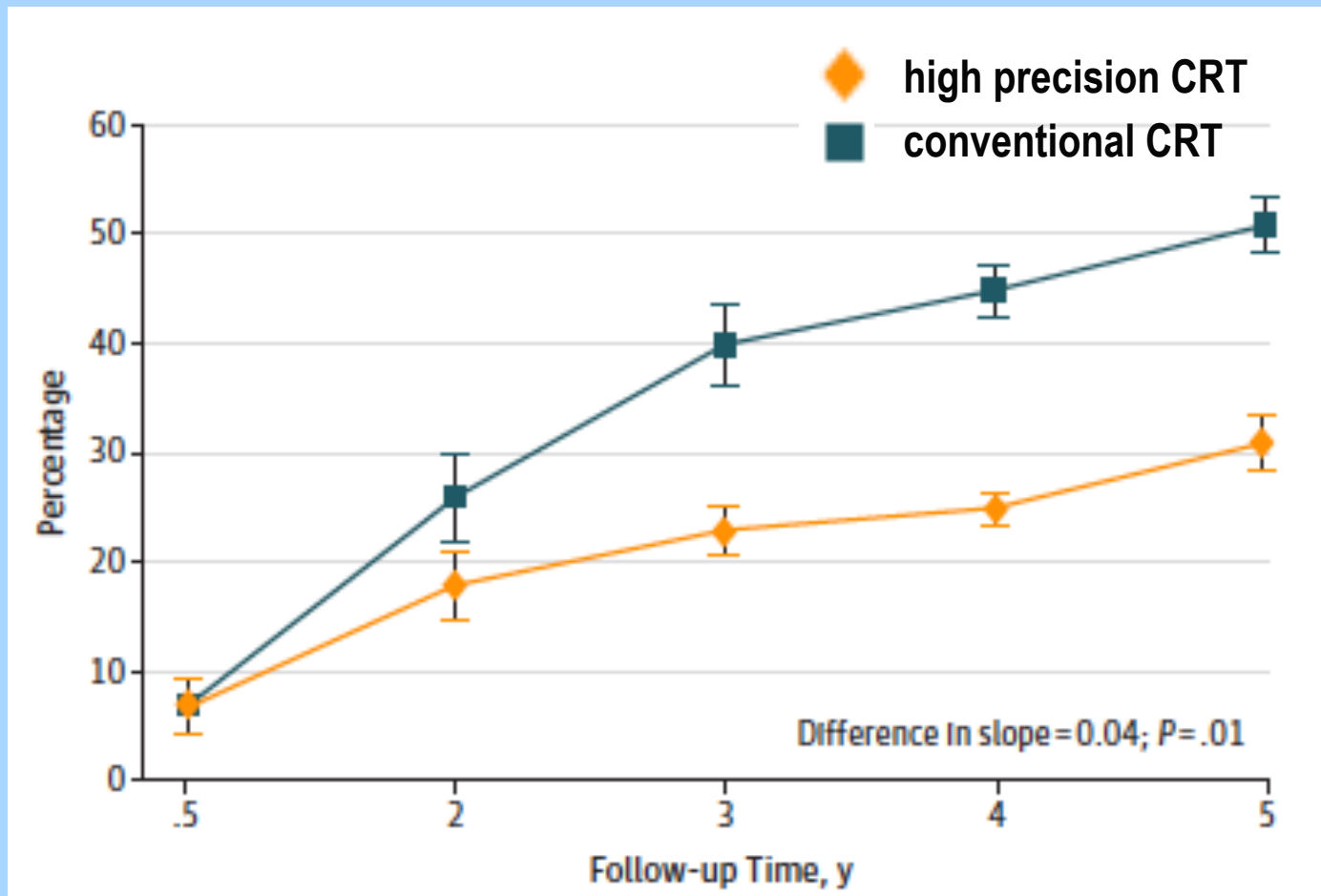
full scale IQ



Benefit of high precision conformal radiotherapy

high precision vs conventional conformal RT

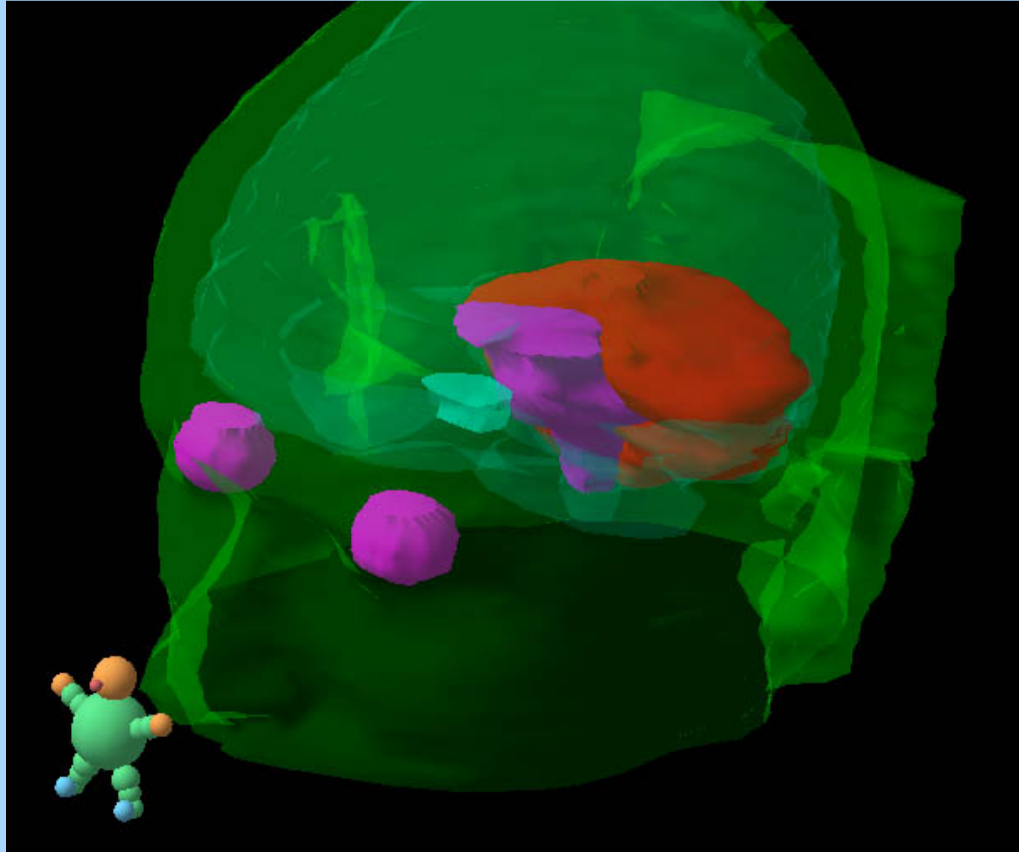
incidence of new endocrine dysfunction



Benefit of high precision conformal radiotherapy

Physical endpoints – normal tissue avoidance

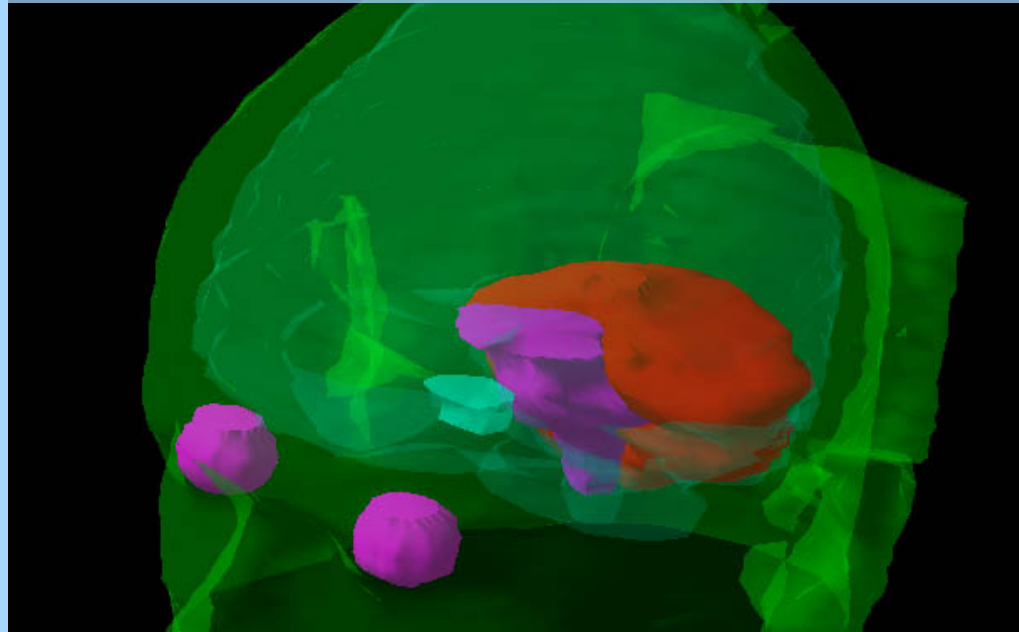
reduce normal tissue volume & dose



Evaluation of local radiotherapy techniques

Physical endpoints – normal tissue avoidance

reduce normal tissue volume & dose



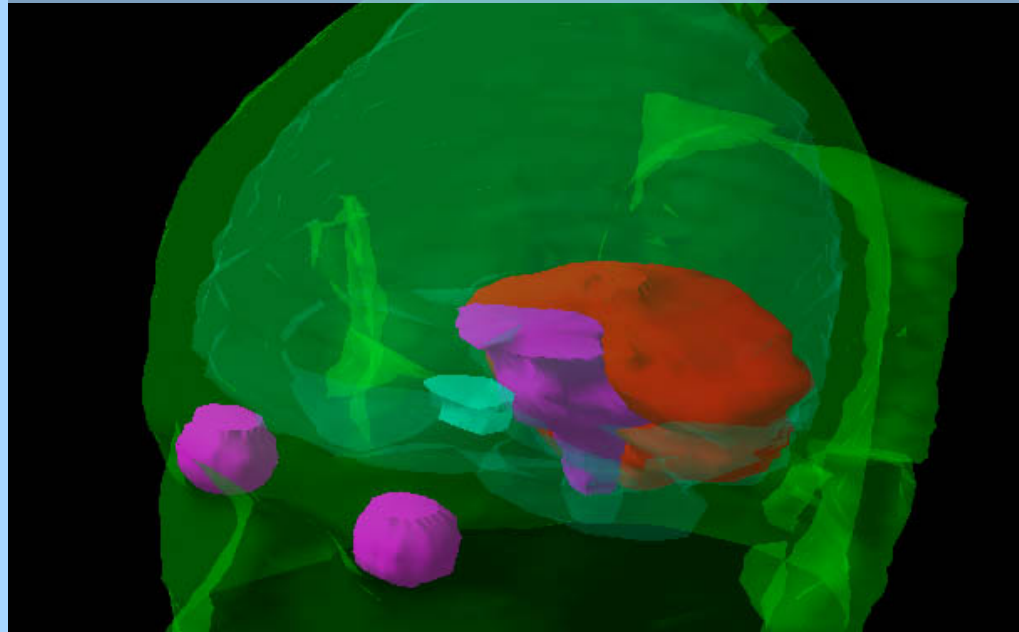
central nervous system
critical structures (OARs)

Evaluation of local radiotherapy techniques

OAR – organ at risk

Physical endpoints – normal tissue avoidance

reduce normal tissue volume & dose



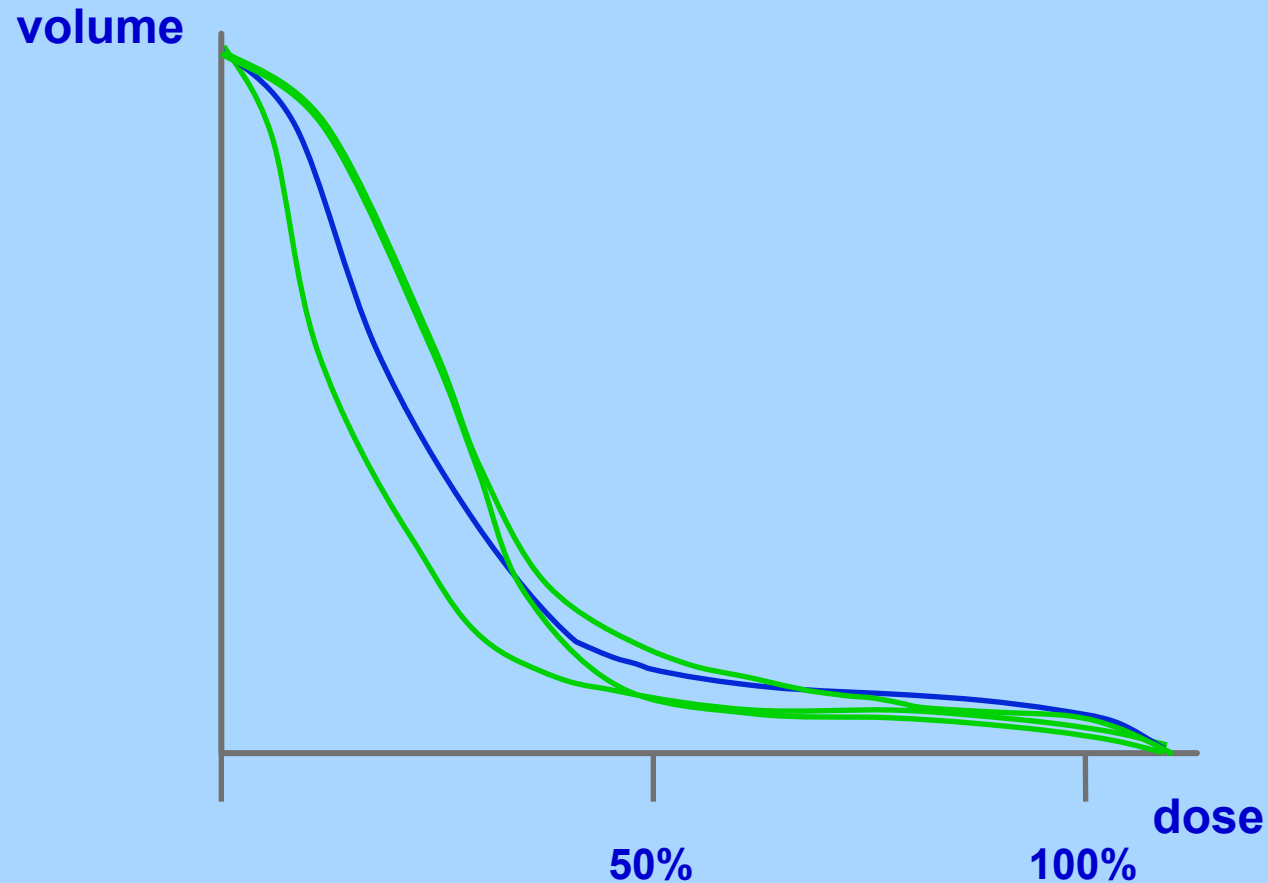
central nervous system
critical structures (OARs)

Evaluation of local radiotherapy techniques

OAR – organ at risk

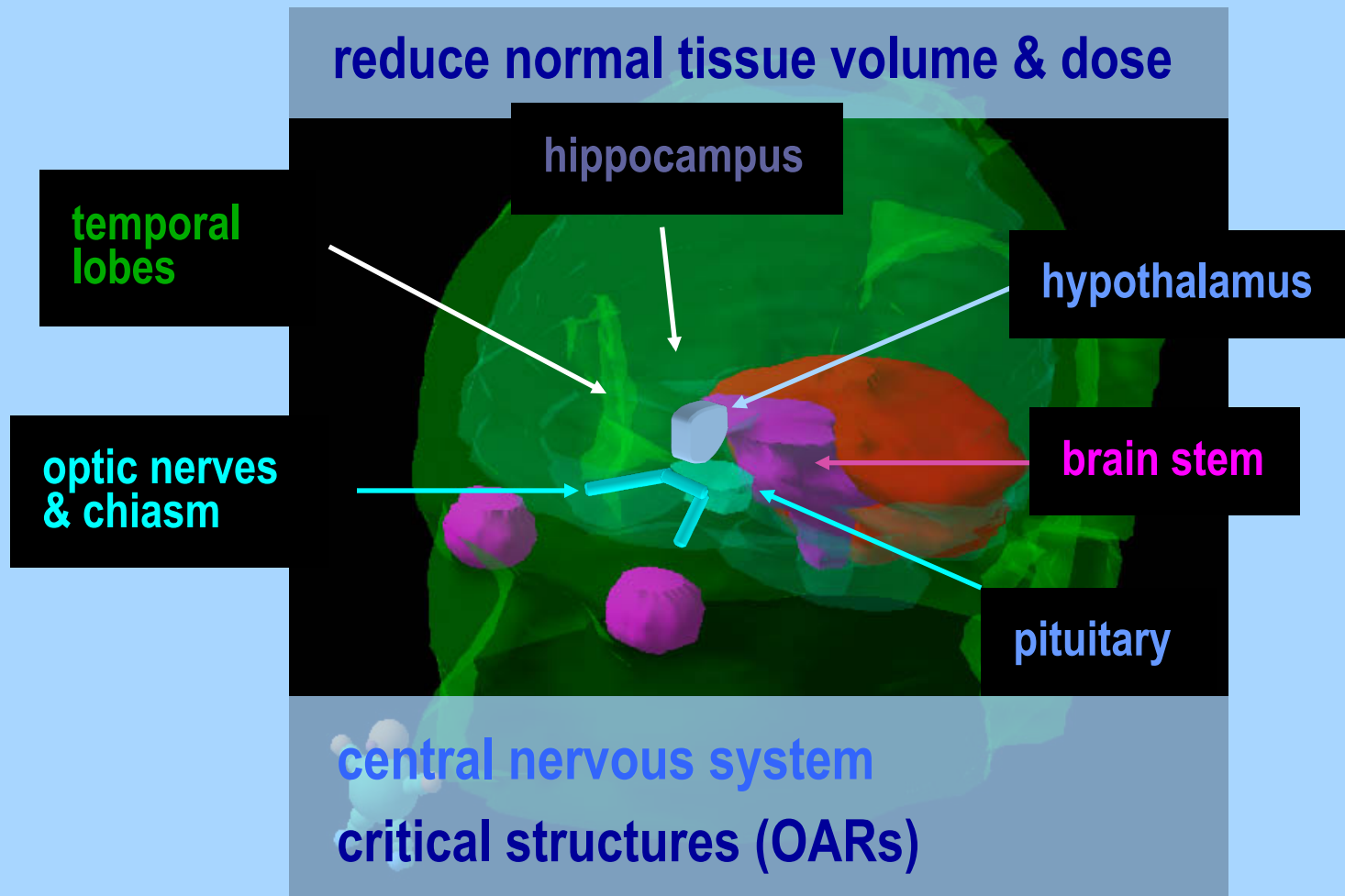
Physical endpoints

central nervous system DVH



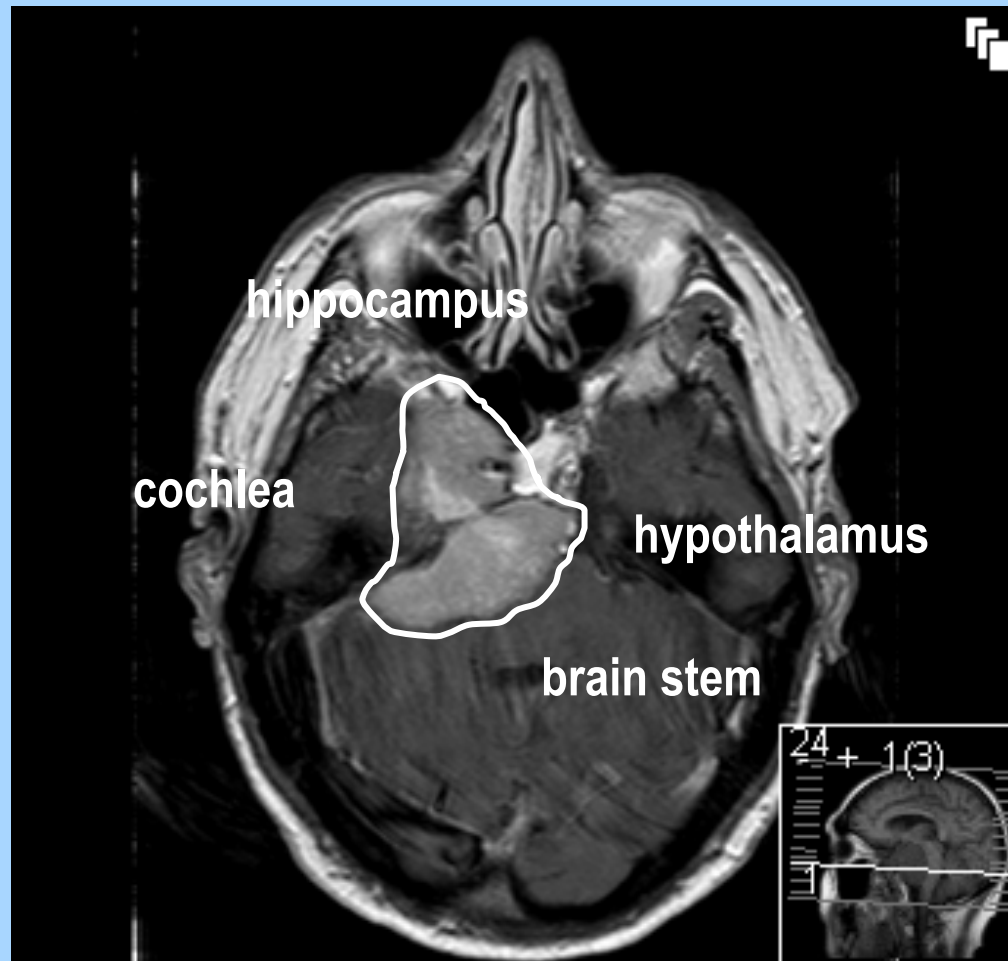
Evaluation of local radiotherapy techniques

Avoidance in the treatment of skull base tumours



Evaluation of local radiotherapy techniques

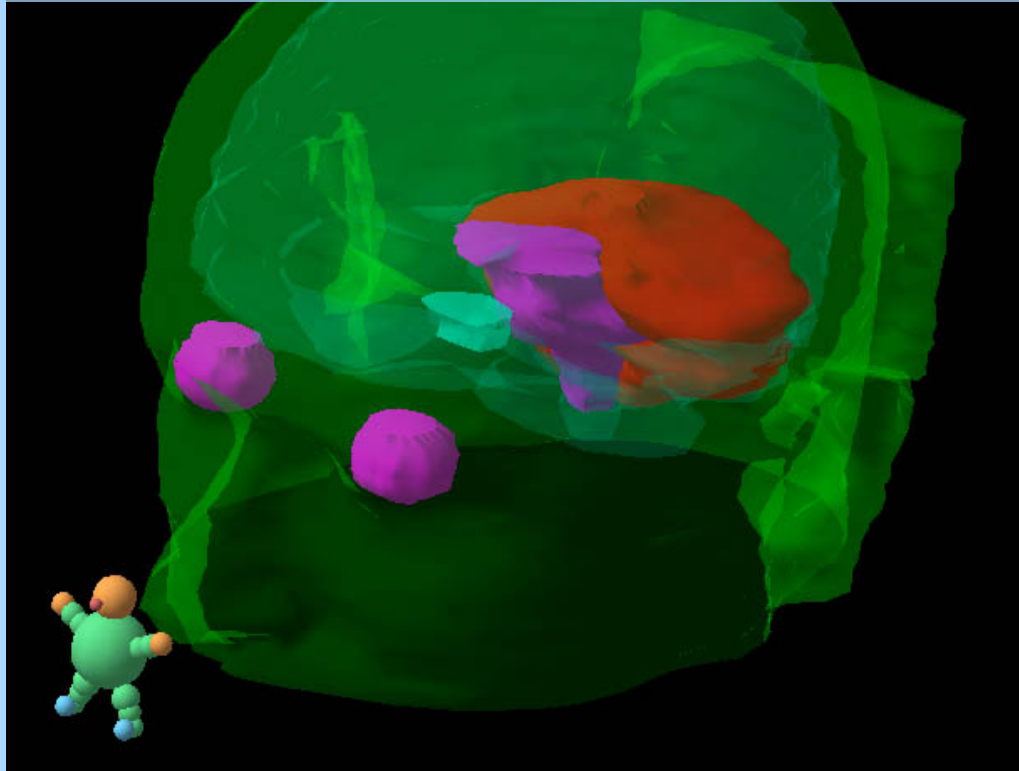
Avoidance in the treatment of skull base tumours



High precision conformal RT for meningioma

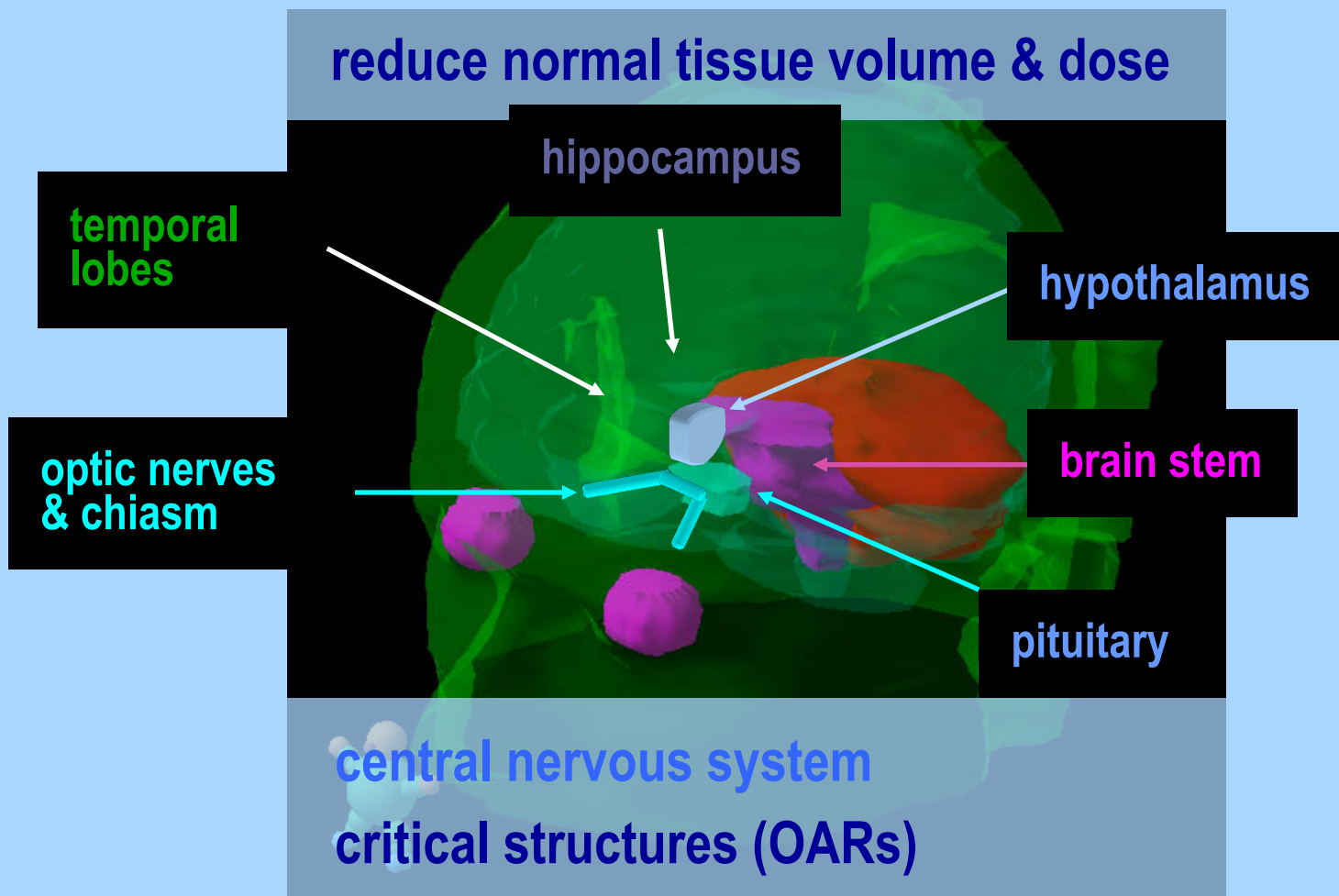
Localised radiation delivery metrics

operator skill
clinical relevance



Evaluation of local radiotherapy techniques

Avoidance in the treatment of skull base tumours



Evaluation of local radiotherapy techniques

In fractionated stereotactic RT of skull base tumours which is the clinically most important structure to avoid?

pituitary

hypothalamus

temporal lobe(s)

brain stem

optic apparatus

hippocampus

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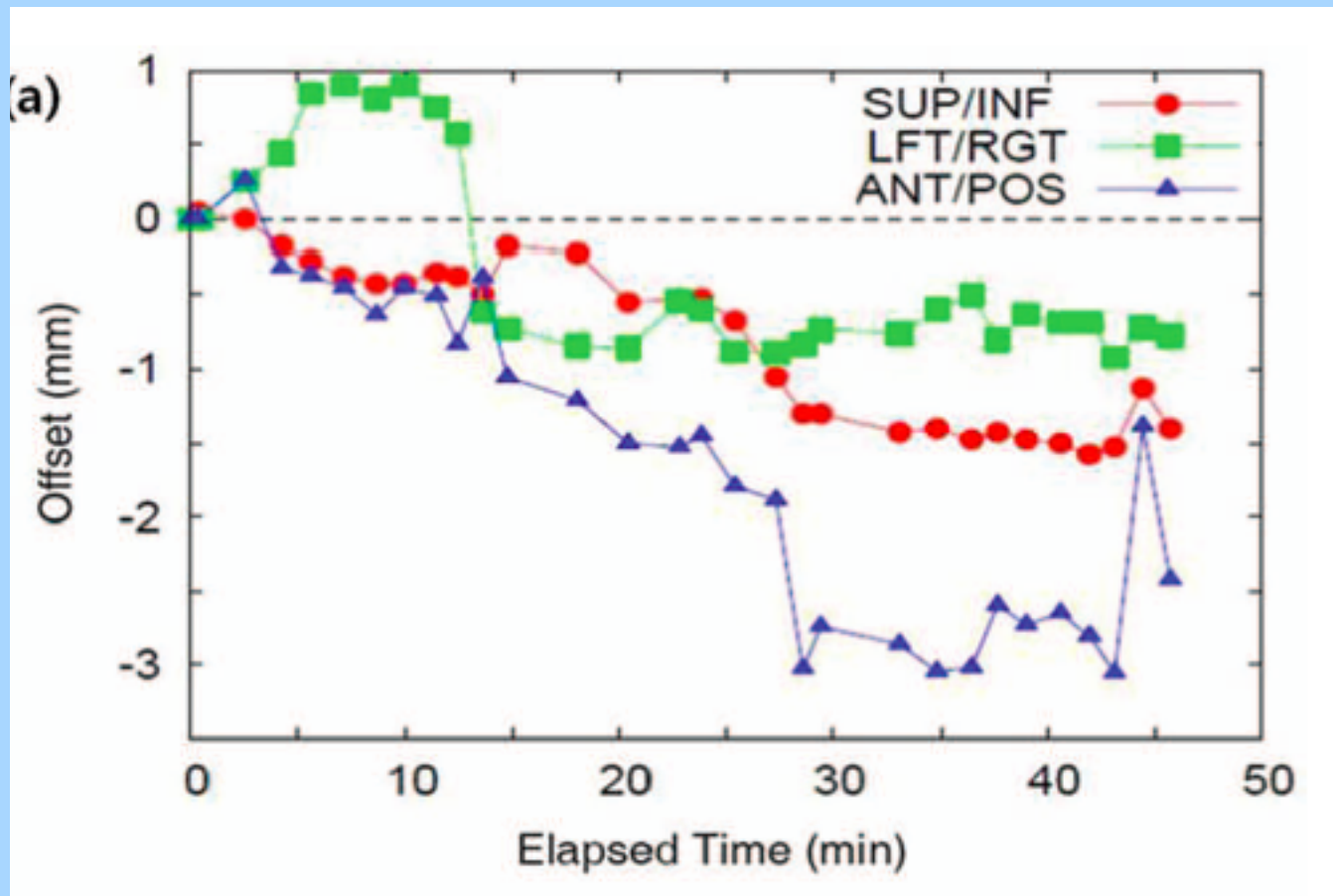
interfraction changes in tumour & normal tissue

quality assurance

imaging closer to treatment delivery (IGRT)

Radiotherapy technologies

example of intrafraction movement



Intrafraction motion in CK radiosurgery

Attributes of modern local RT delivery

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imaging closer to treatment delivery (IGRT)

Radiotherapy technologies

IGRT - adaptive radiotherapy adjusting for interfraction motion

**change in tumour
position**

**change in tumour
shape & volume**

Radiotherapy of intracranial tumours

IGRT - adaptive radiotherapy adjusting for interfraction motion

**change in tumour
position**

**change in tumour
shape & volume**

Radiotherapy of intracranial tumours

IGRT - adaptive radiotherapy adjusting for interfraction motion

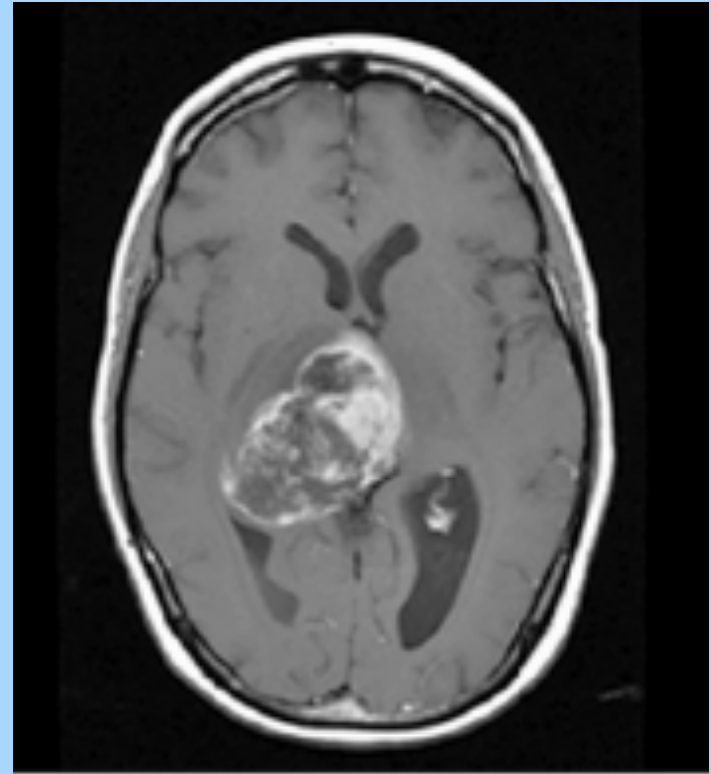
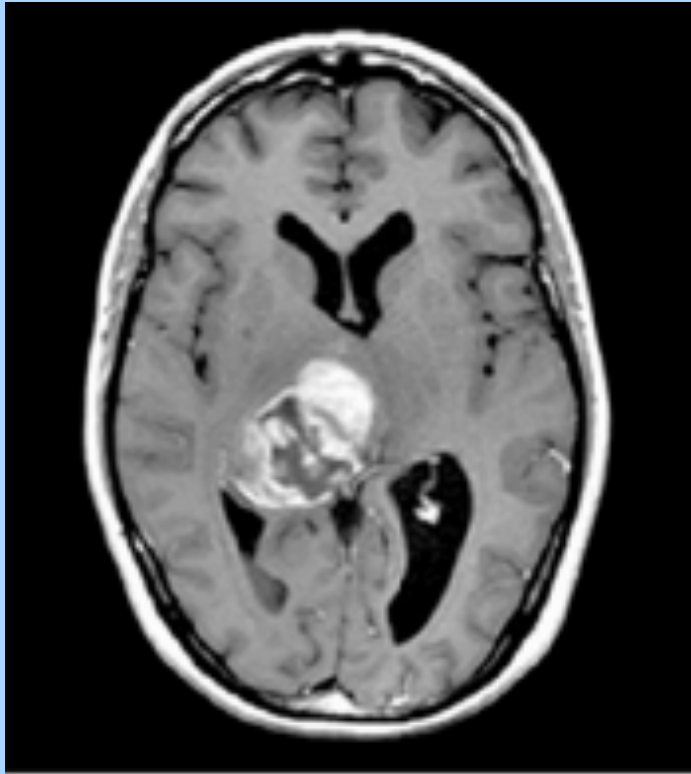
change in tumour
position

change in tumour
shape & volume

Radiotherapy of intracranial tumours

adaptive radiotherapy (IGRT) - interfraction change in size and shape

glioblastoma pseudoprogression



1 month post radiotherapy

Adaptation in brain tumour radiotherapy

adaptive radiotherapy (IGRT) - interfraction change in size and shape

craniopharyngioma



Adaptation in brain tumour radiotherapy

adaptive radiotherapy (IGRT) - interfraction change in size and shape
craniopharyngioma - cystic enlargement



Adaptation in brain tumour radiotherapy

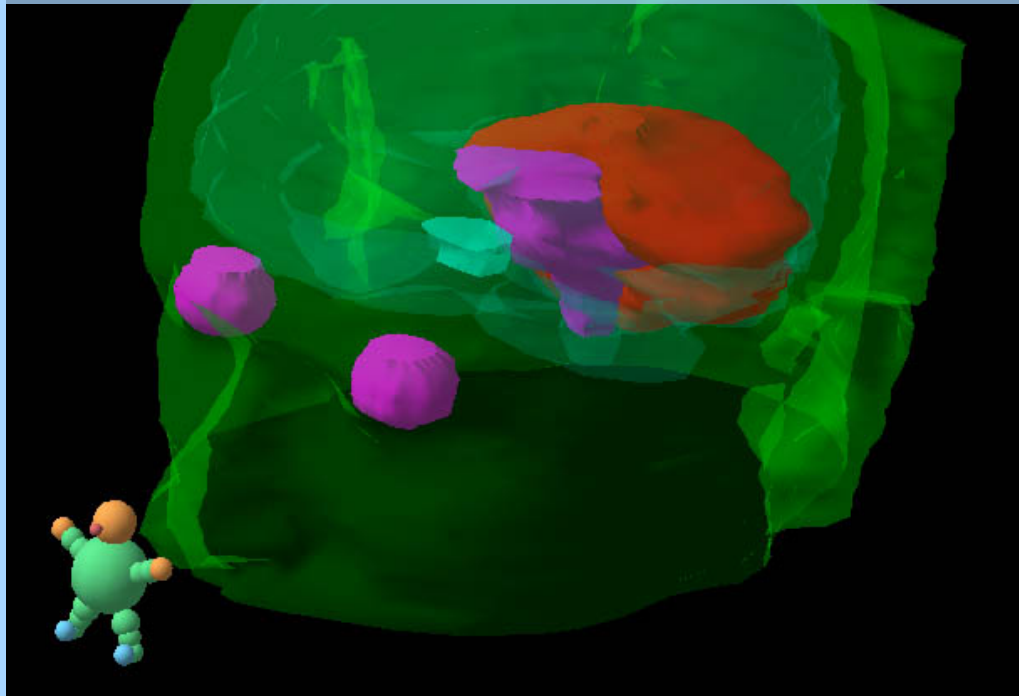
adaptive radiotherapy (IGRT) - interfraction change in size and shape
craniopharyngioma - cystic enlargement



Adaptation in brain tumour radiotherapy

Localised radiation delivery

physical endpoints
standards for comparison
clinical relevance



Evaluation of local radiotherapy techniques

Attributes of modern local RT delivery

refinements of conformal radiotherapy



precision

conformality

photons

protons

time factor (4D RT)

technical and clinical skill

quality assurance

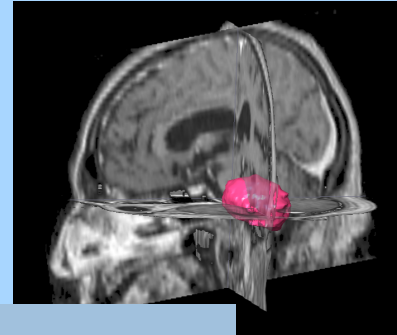
imaging closer to treatment delivery (IGRT)

Classification of radiotherapy technologies

technical aspects of cranial RT	RT & SRT in benign brain tumours
RT & SRT in malignant brain tumours	outcome of SRT

Radiotherapy for primary brain tumours

Principles



indolent tumours

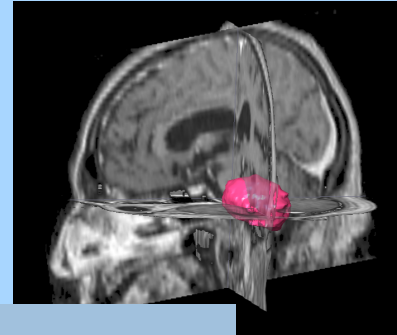
long natural history

rarely life threatening

radiotherapy - one of available options

Management of benign brain tumours

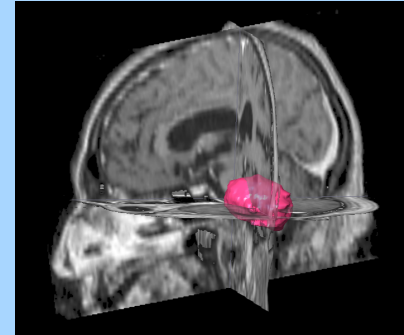
Radiotherapy prerequisites



need to understand:
natural history
imaging
other treatment options

balance of risks

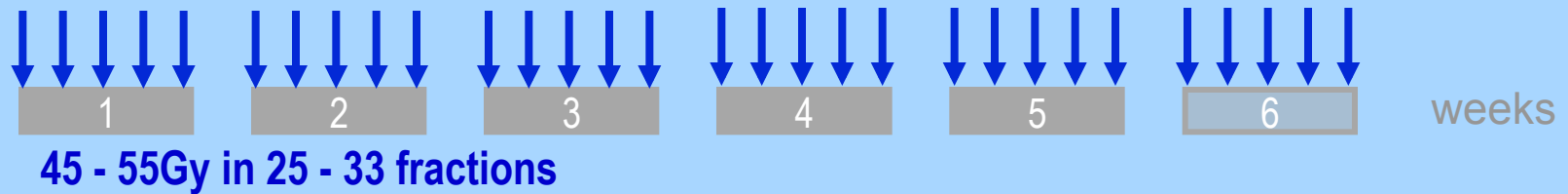
Management of benign brain tumours



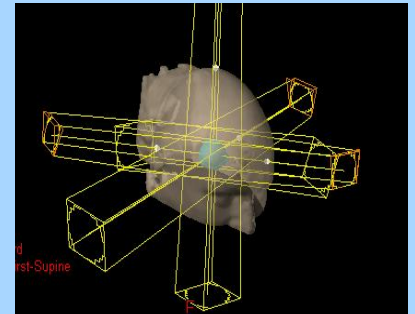
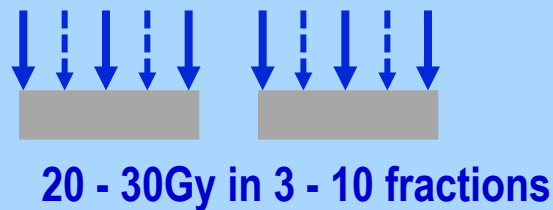
Surveillance	Surgery
Radiotherapy	Medical therapy

Management options in benign brain tumours

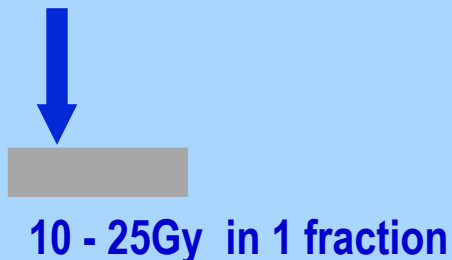
Fractionated radiotherapy



Hypofractionated radiotherapy



Single fraction radiotherapy (radiosurgery)



Dose fractionation in benign brain tumours

Benign brain tumours

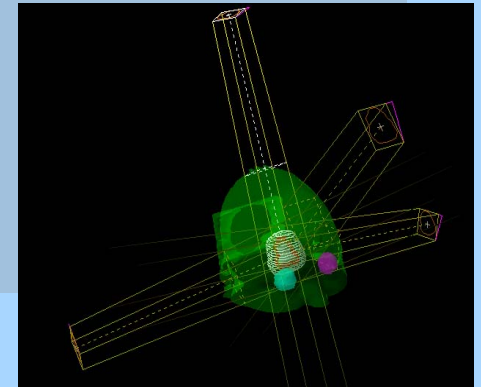
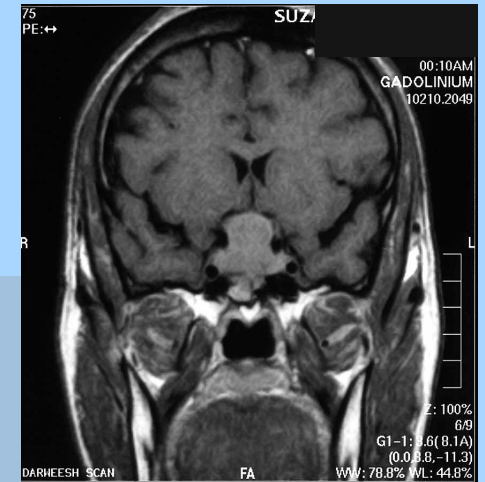
pituitary adenoma

craniopharyngioma

acoustic neuroma

skull base meningioma

childhood low grade glioma



Management of benign brain tumours

Benign brain tumours

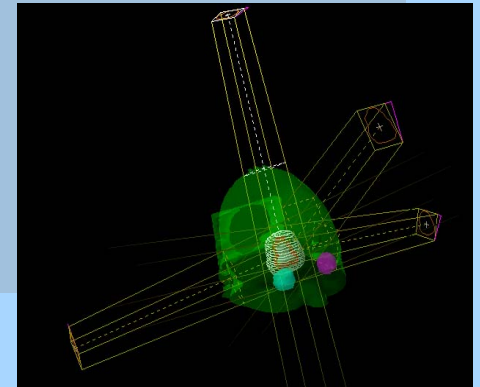
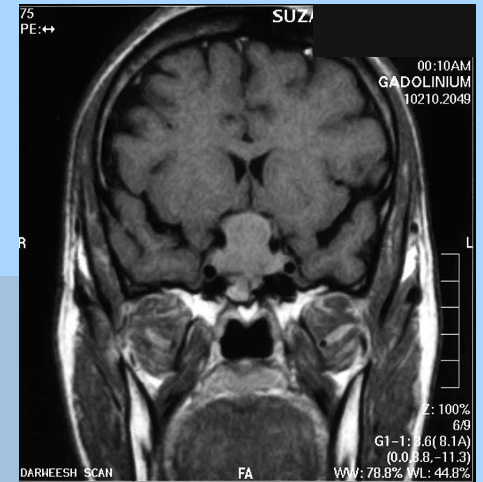
pituitary adenoma

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childhood low grade glioma



Management of benign brain tumours



Surveillance	Surgery
Radiotherapy	Medical therapy

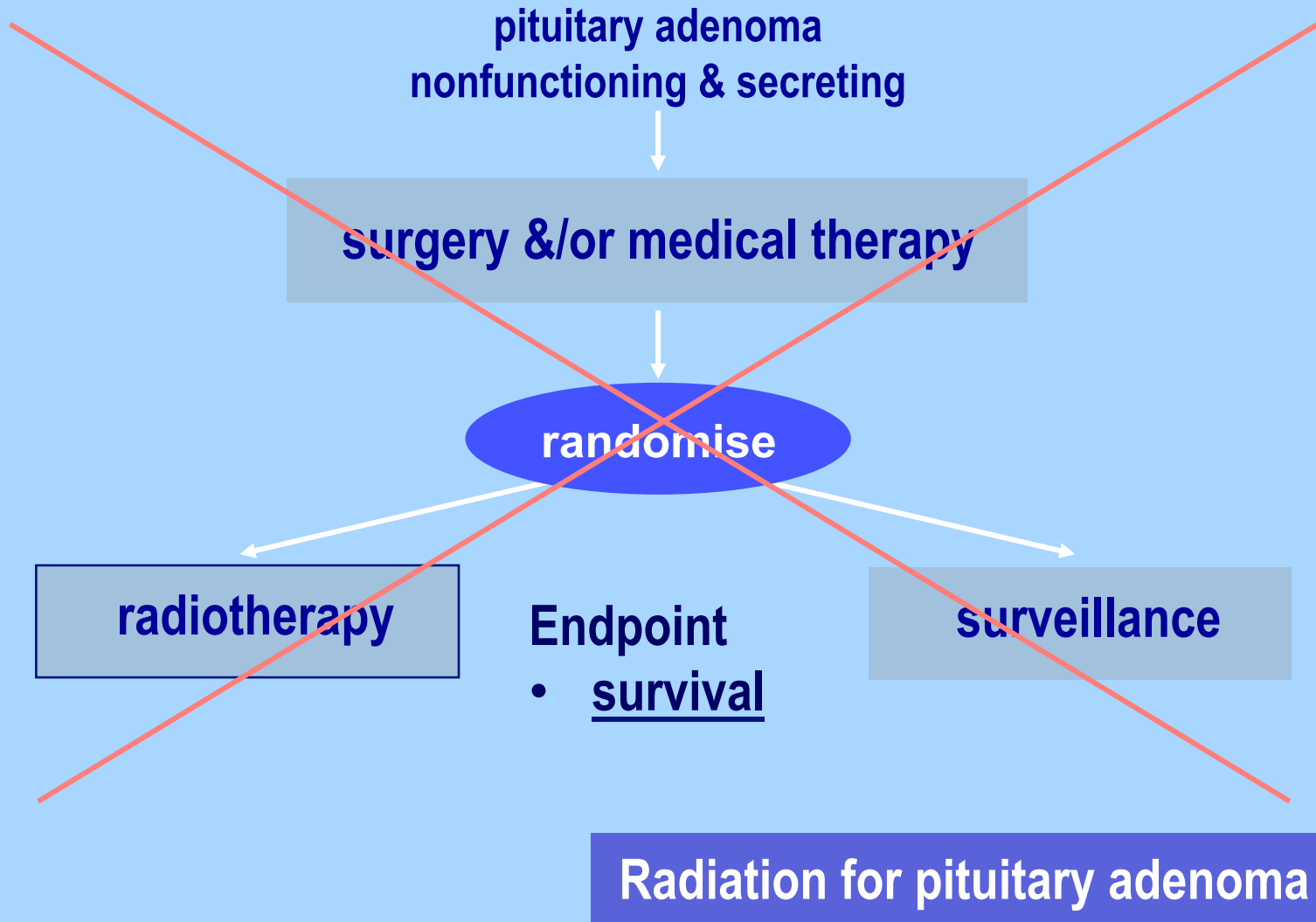
Management options in pituitary adenoma



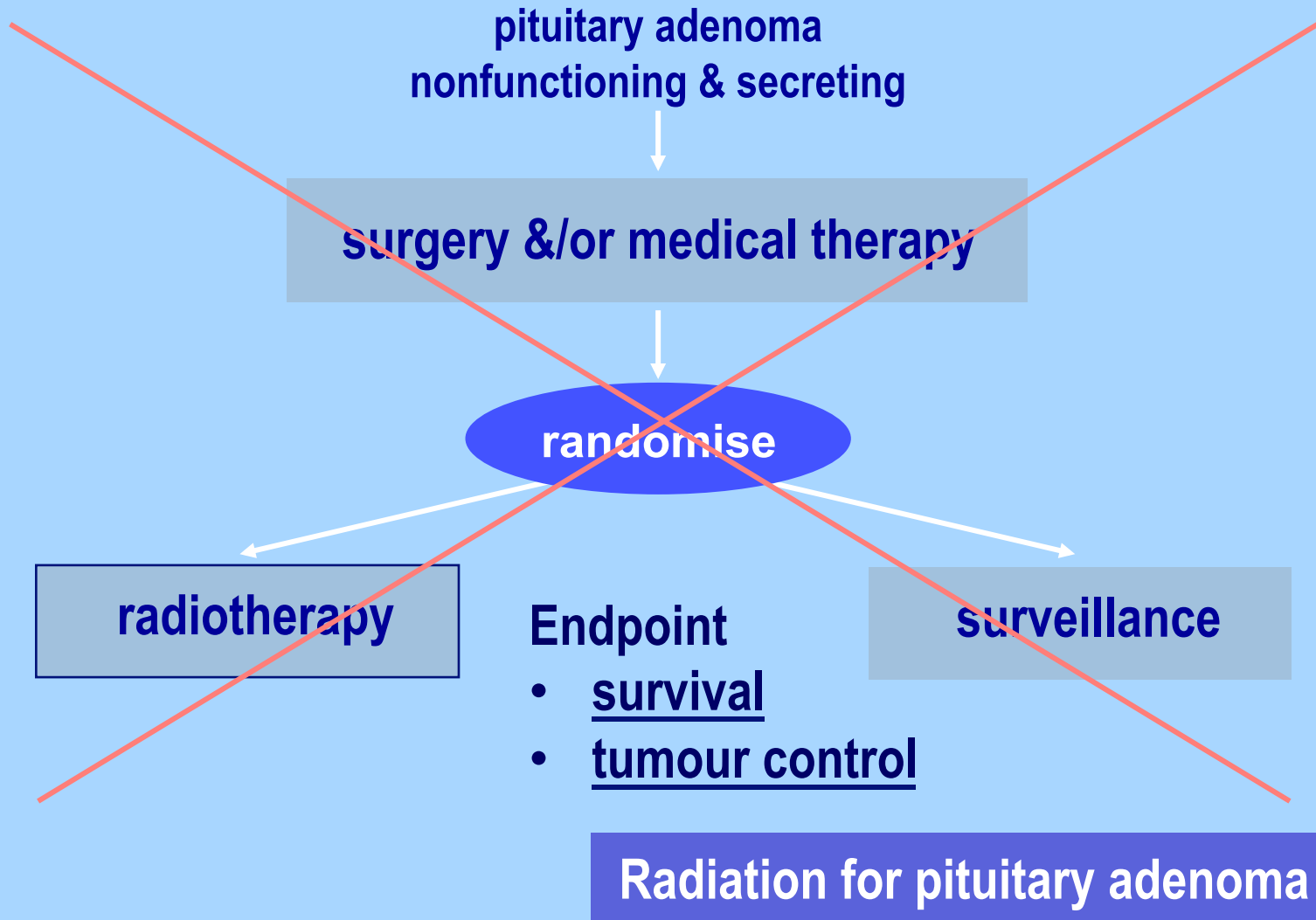
Surveillance	Surgery
Radiotherapy	Medical therapy

Management options in pituitary adenoma

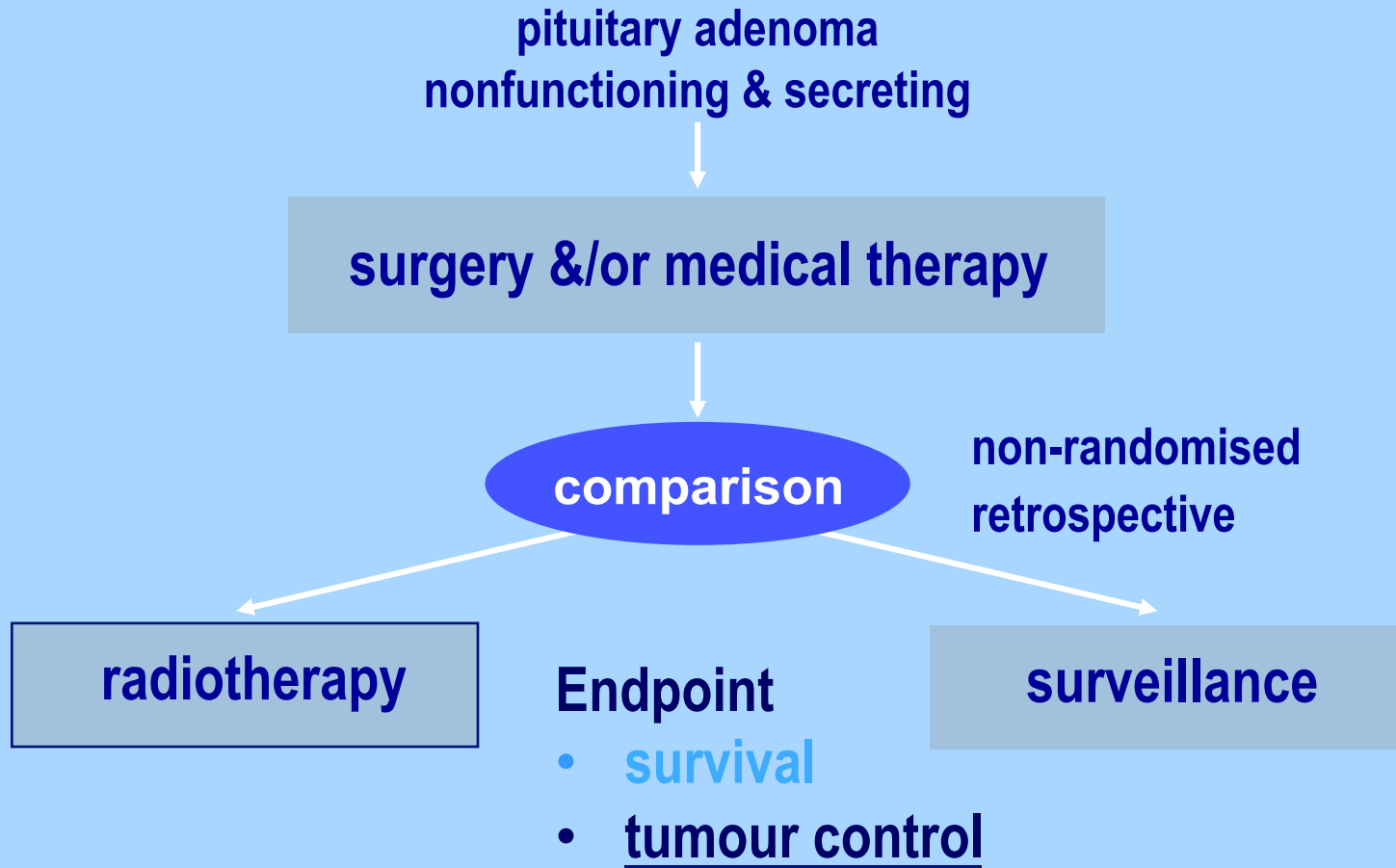
Benefit of radiotherapy



Benefit of radiotherapy

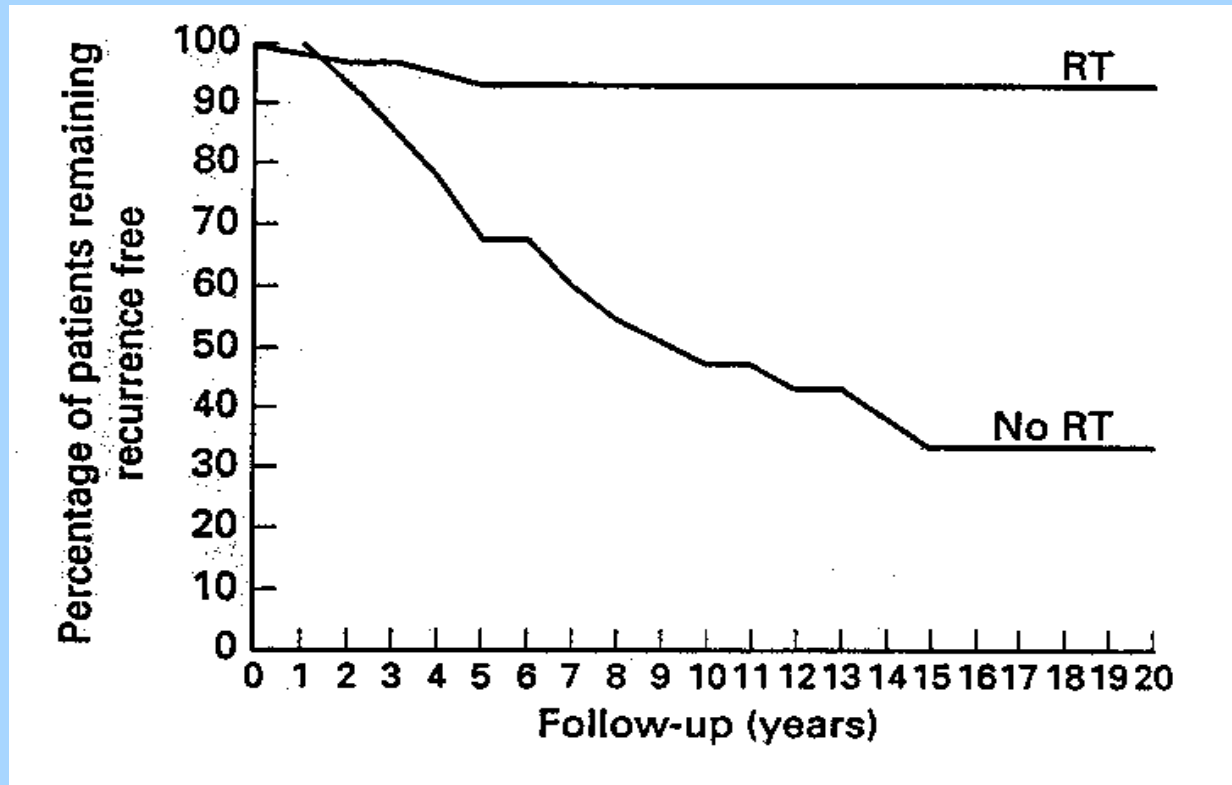


Benefit of radiotherapy



Radiation for pituitary adenoma

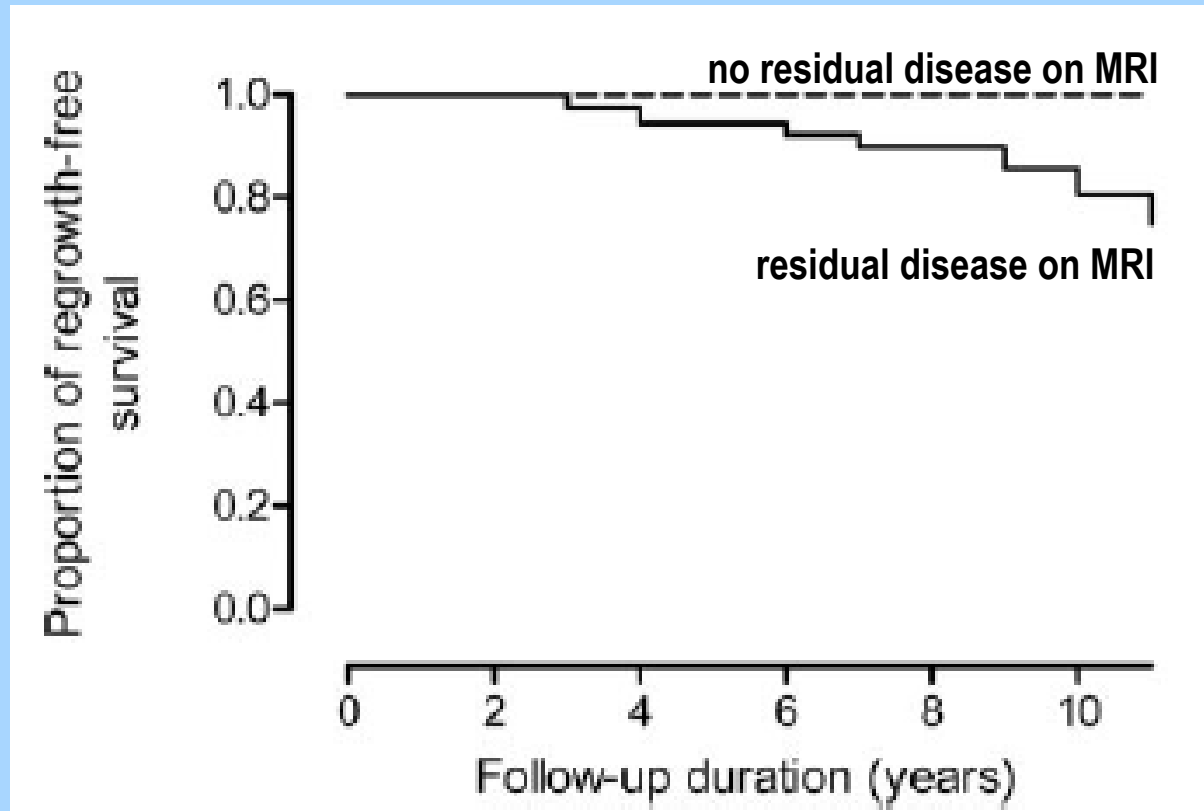
Progression after surgery



2 centre policy (non-randomized), 126 patients

Residual pituitary adenoma

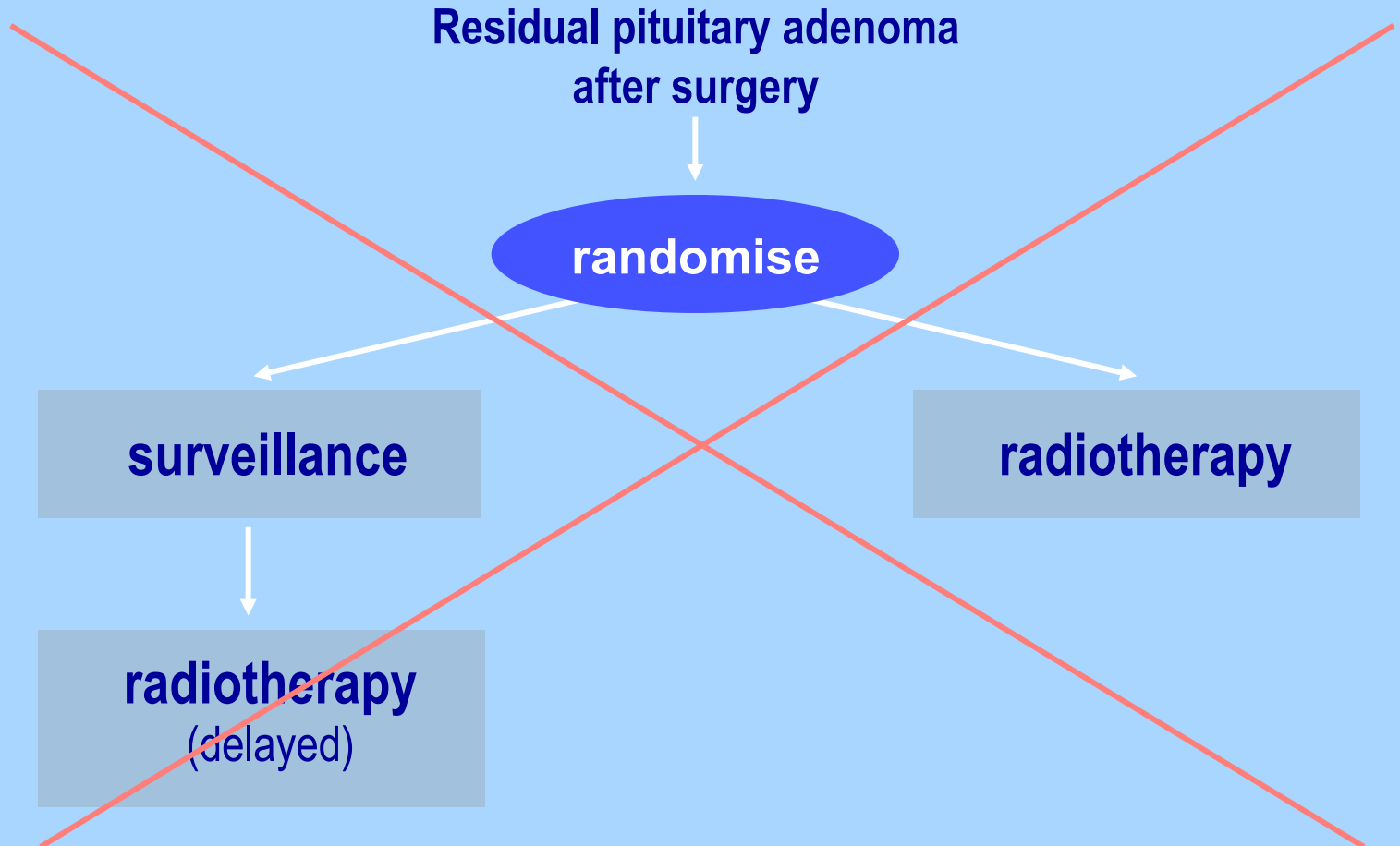
Progression after surgery



109 pts with non-functioning adenoma, median FU 6 years

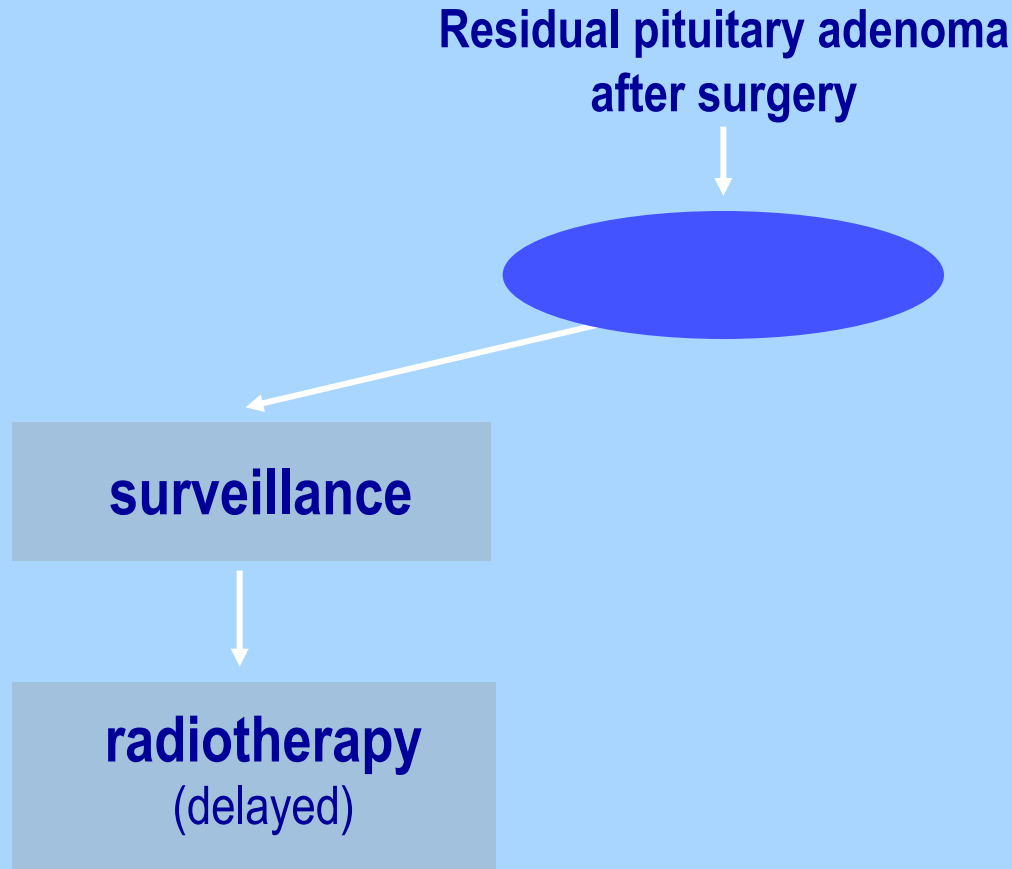
Residual pituitary adenoma

Timing of radiotherapy



Radiation for pituitary adenoma

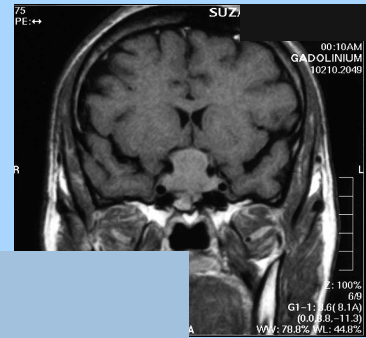
Timing of radiotherapy



Radiation for pituitary adenoma

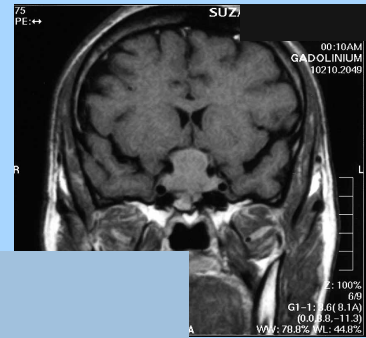
Indications for radiotherapy

Non-functioning pituitary adenoma
progressive tumour
following primary surgery
presumed threat to function



Management options in pituitary adenoma

Indications for radiotherapy



Non-functioning pituitary adenoma

progressive tumour

following primary surgery

presumed threat to function

Hormone secreting pituitary adenoma

persistent hormone elevation after surgery

to withdraw medical treatment

Management options in pituitary adenoma

Benign brain tumours

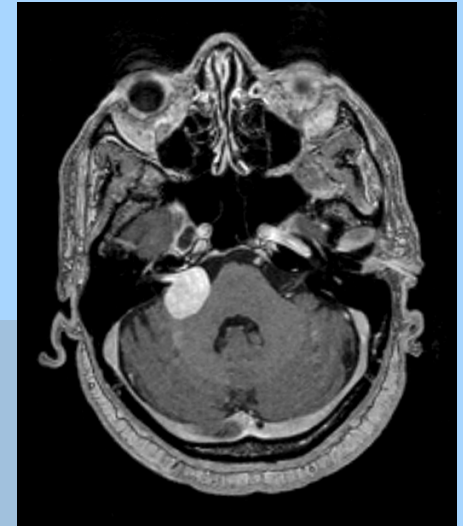
pituitary adenoma

craniopharyngioma

acoustic neuroma

skull base meningioma

childhood low grade glioma



Management of benign brain tumours

Acoustic neuroma and radiotherapy

tumour control is dose dependent

radiotherapy can be associated with
life threatening complications

early radiotherapy preserves hearing

surveillance prior to radiotherapy is
associated with risk of facial palsy

all of theses

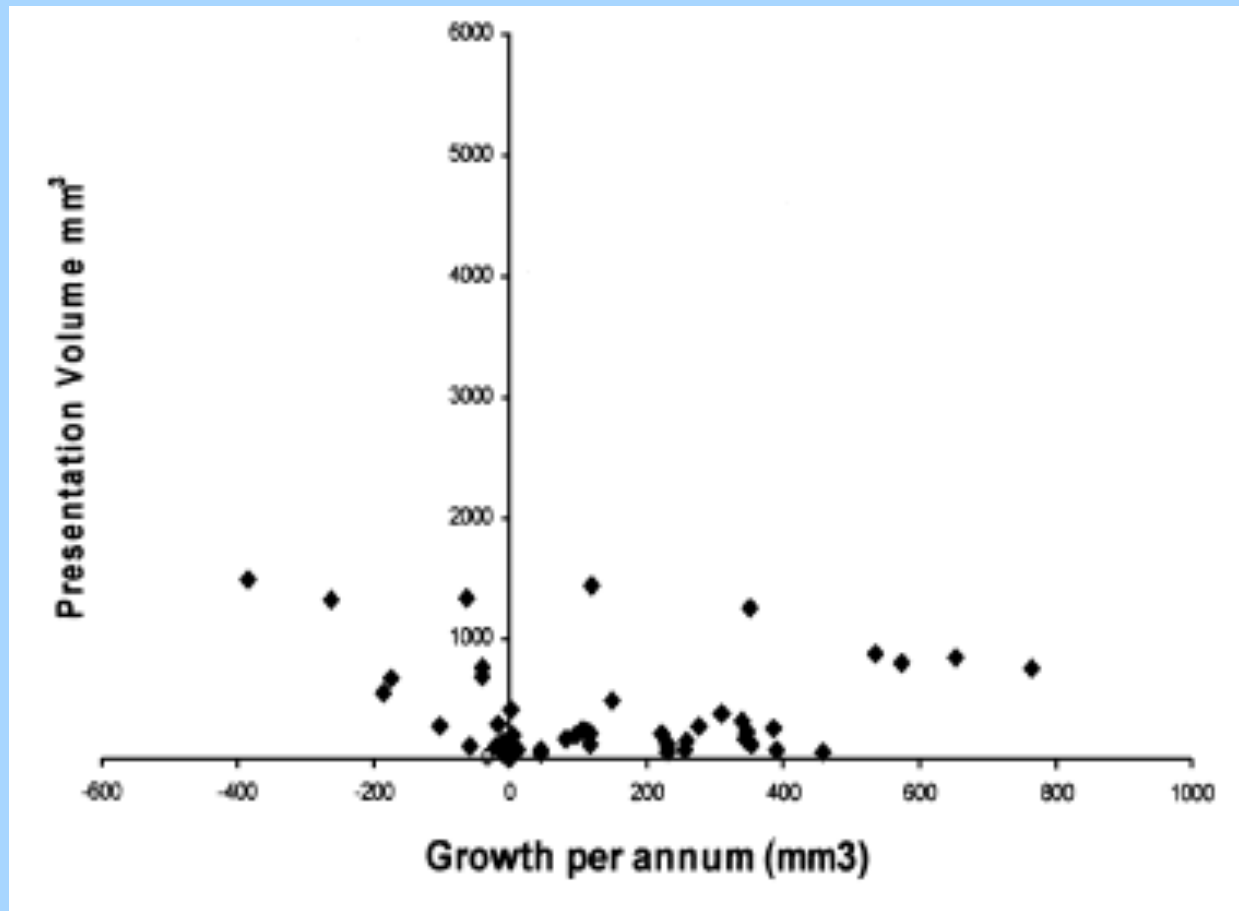
none of these

surveillance	surgery
radiotherapy	medical therapy

Management options in vestibular schwannoma

surveillance	surgery
radiotherapy	medical therapy

Management options in vestibular schwannoma



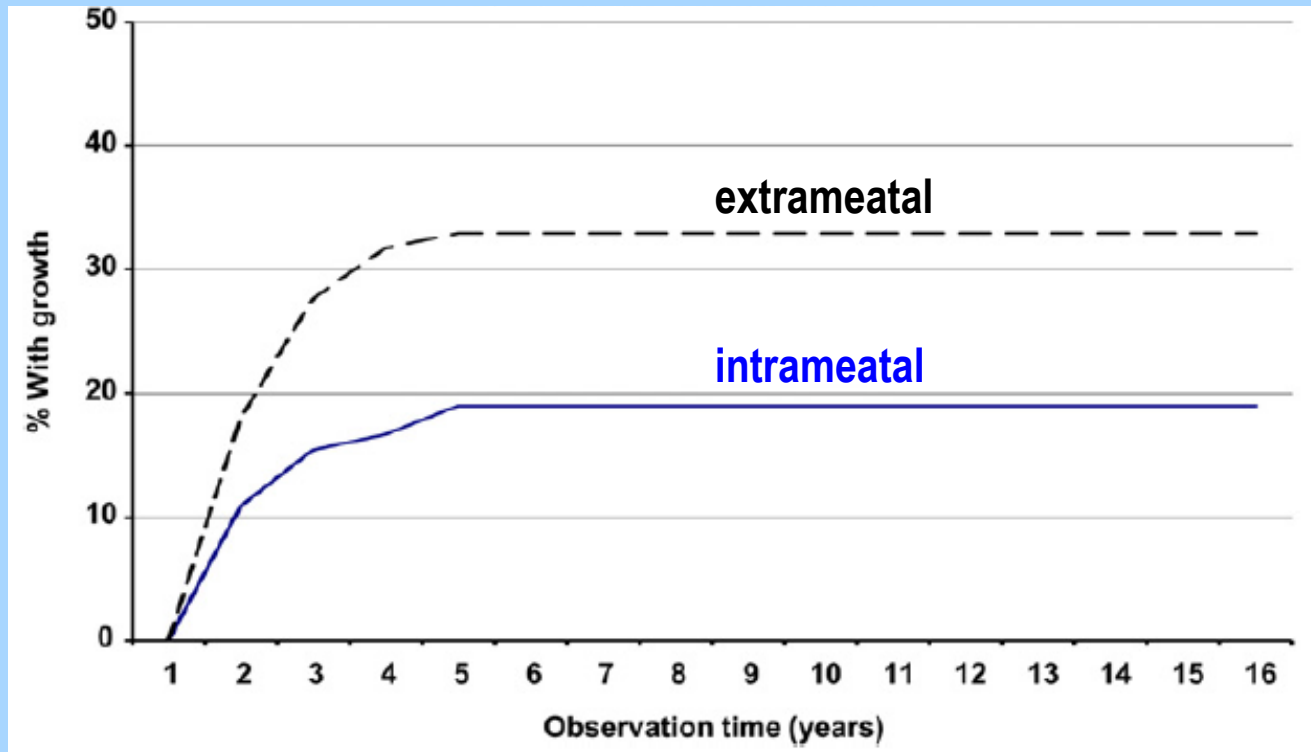
Herwadker et al 2005
Manchester

Surveillance

growth on surveillance

Danish cohort

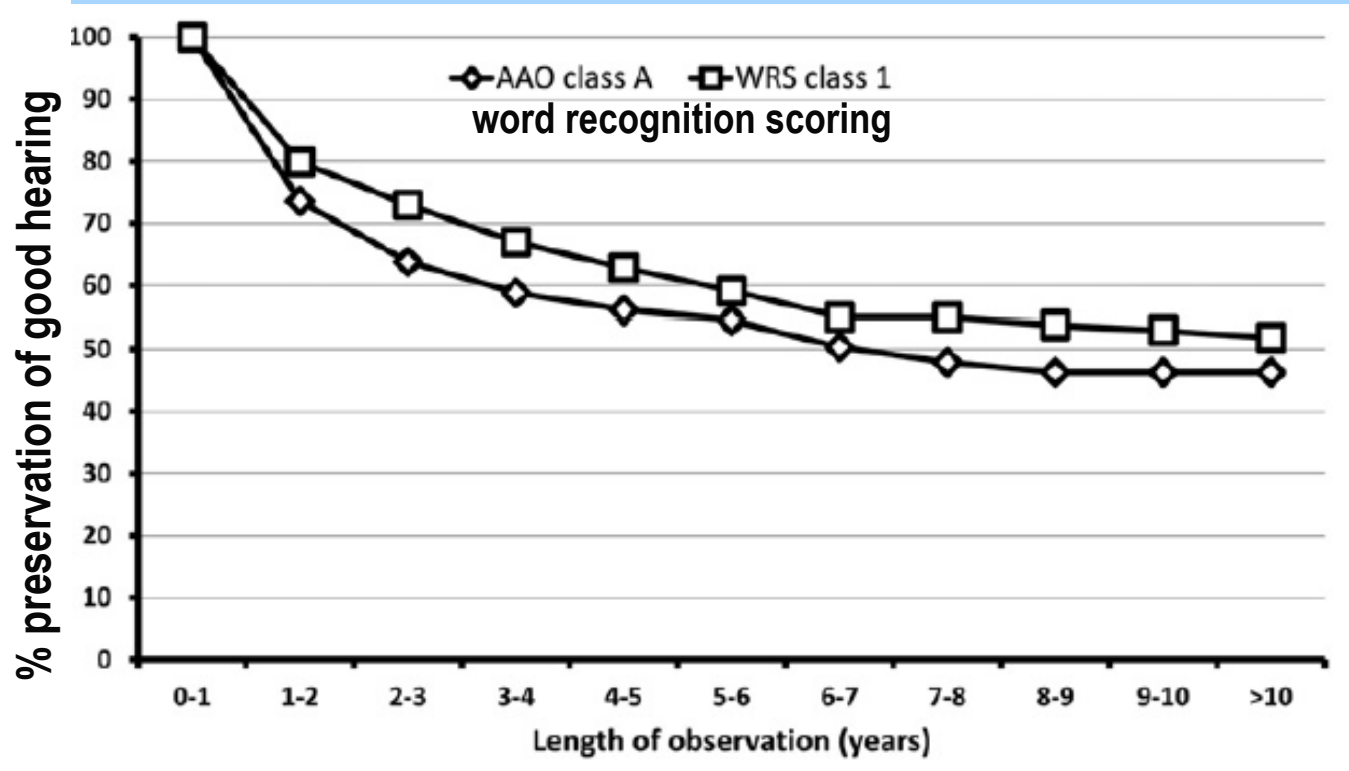
AN \leq 2cm max diameter (sporadic)



hearing loss on surveillance

Danish cohort

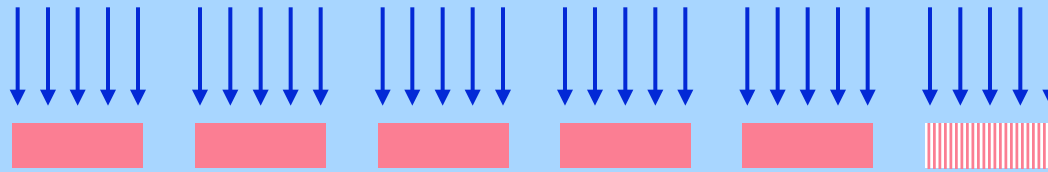
AN ≤ 2 cm max diameter (sporadic)



surveillance	surgery
radiotherapy	medical therapy

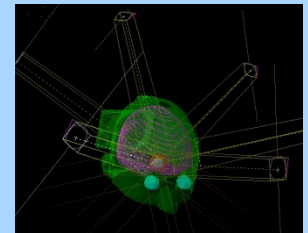
Management options in vestibular schwannoma

Fractionated “stereotactic” radiotherapy

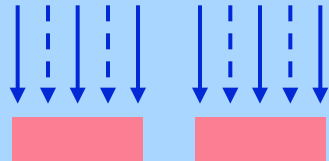


45 - 50Gy in 25 - 30 fractions

fractions
weeks

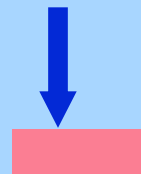


Hypofractionated “stereotactic” radiotherapy

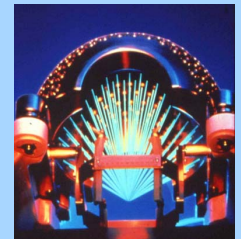


20 - 30Gy in 6 - 10 fractions

Single fraction radiosurgery

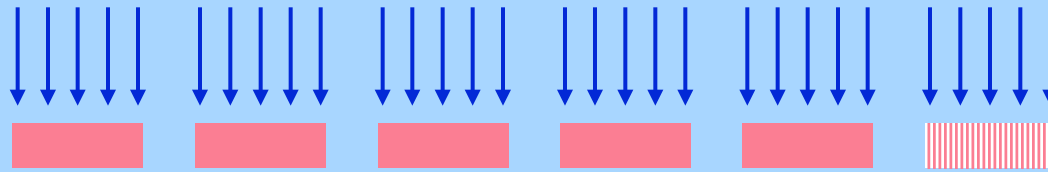


10 - 25Gy in 1 fraction



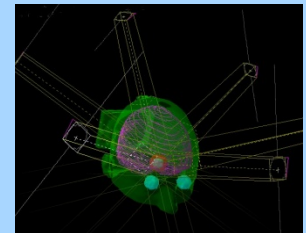
Fractionation in high precision radiotherapy

Fractionated “stereotactic” radiotherapy

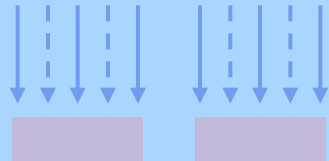


45 - 50Gy in 25 - 30 fractions

fractions
weeks

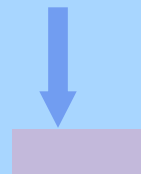


Hypofractionated “stereotactic” radiotherapy

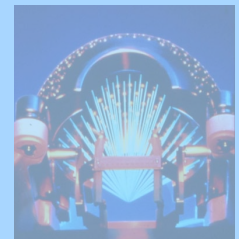


20 - 30Gy in 6 - 10 fractions

Single fraction radiosurgery



10 - 25Gy in 1 fraction

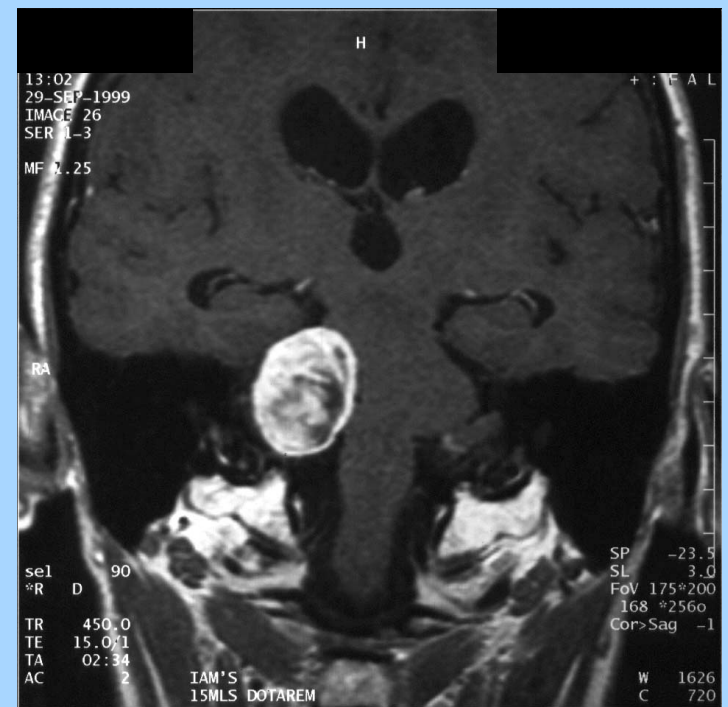


Fractionation in high precision radiotherapy

Transient enlargement & hydrocephalus



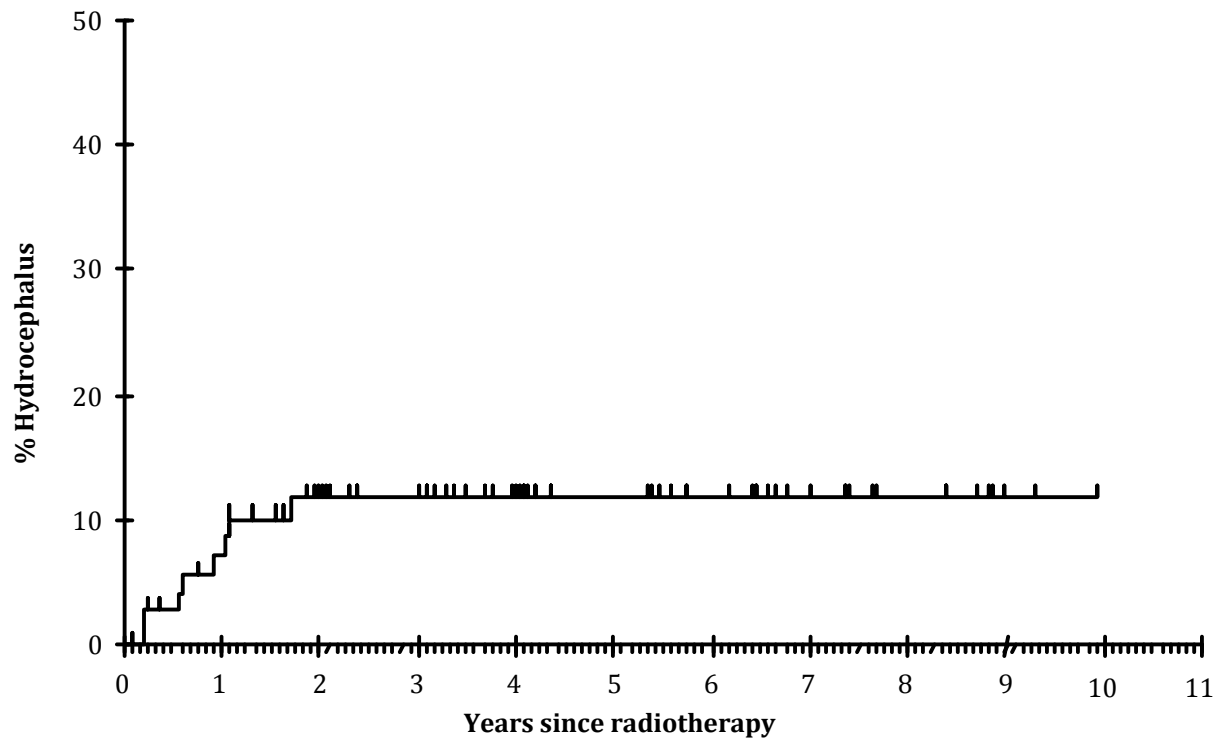
23/4/1998



29/9/1999

Stereotactic RT for acoustic neuroma

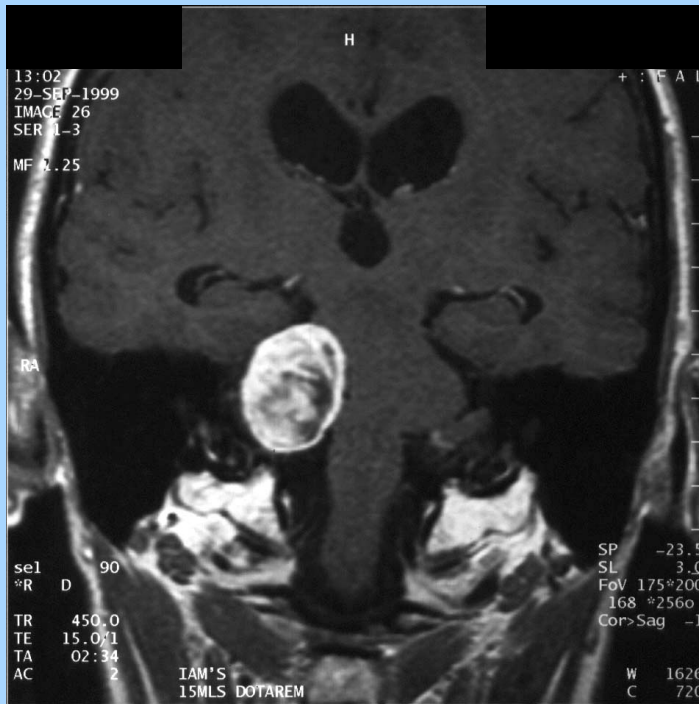
Incidence of hydrocephalus



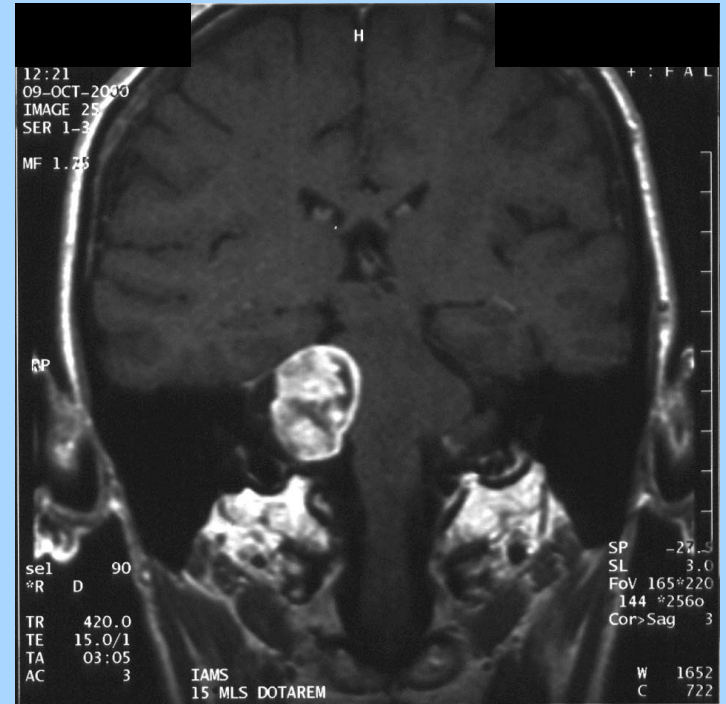
72 patients with acoustic neuroma, fSRT, Royal Marsden Hospital

Stereotactic RT for acoustic neuroma

Transient enlargement resolution



29/9/1999



9/10/2000

Stereotactic RT for acoustic neuroma

Benign brain tumours

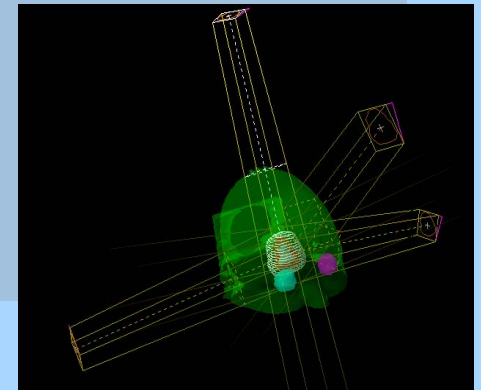
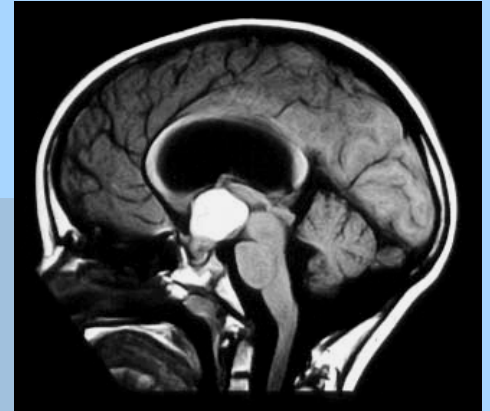
pituitary adenoma

craniopharyngioma

acoustic neuroma

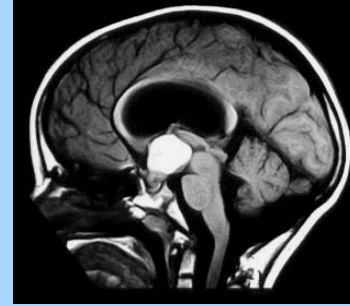
skull base meningioma

childhood low grade glioma



Management of benign brain tumours

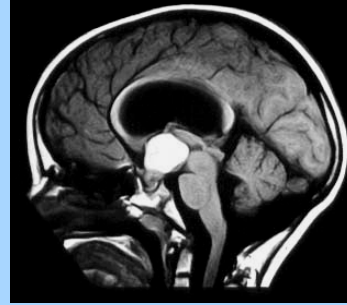
Primary therapy



Surveillance	Surgery
Radiotherapy	Medical therapy

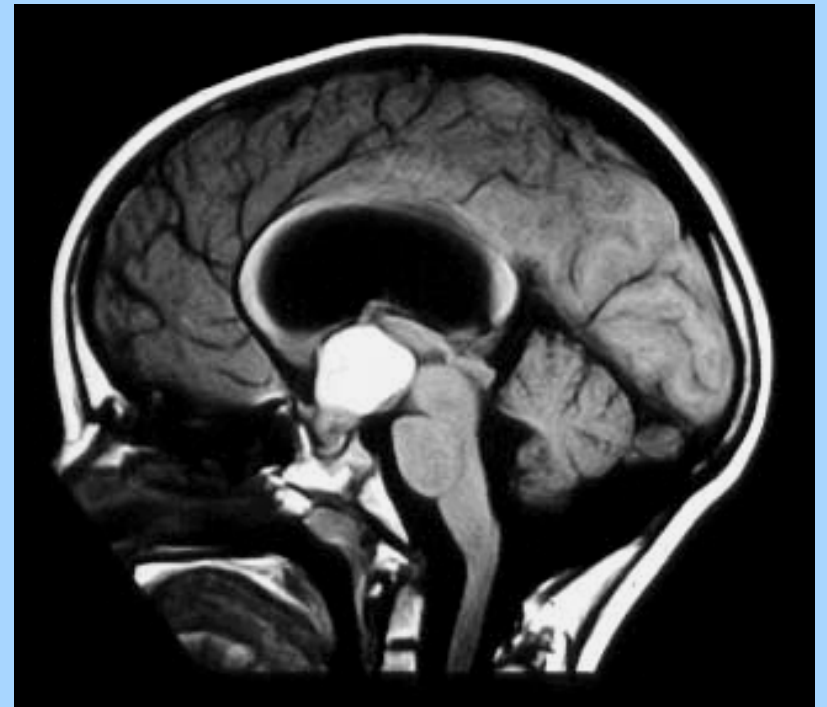
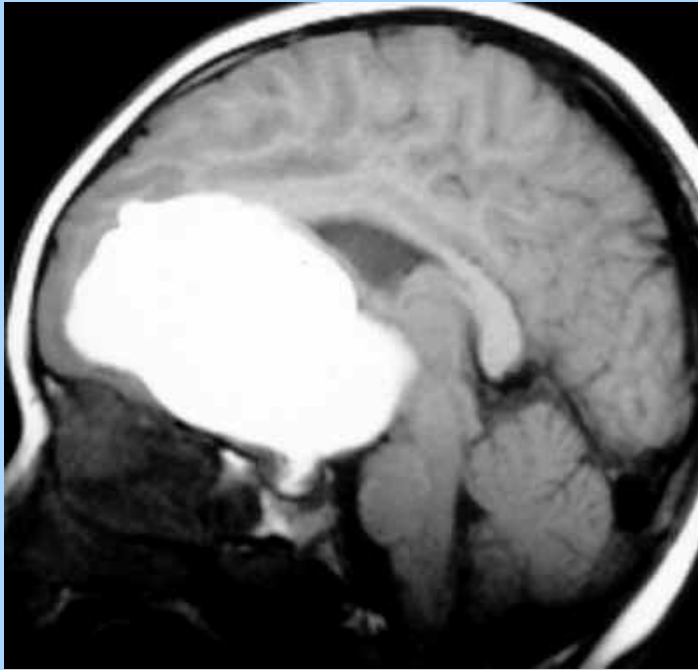
Management options in craniopharyngioma

Primary therapy



Surveillance	Surgery
Radiotherapy	Medical therapy

Management options in craniopharyngioma



Surgery for craniopharyngioma

Practical issues

target volume

cystic enlargement

image guidance

Craniopharyngioma management

Practical issues

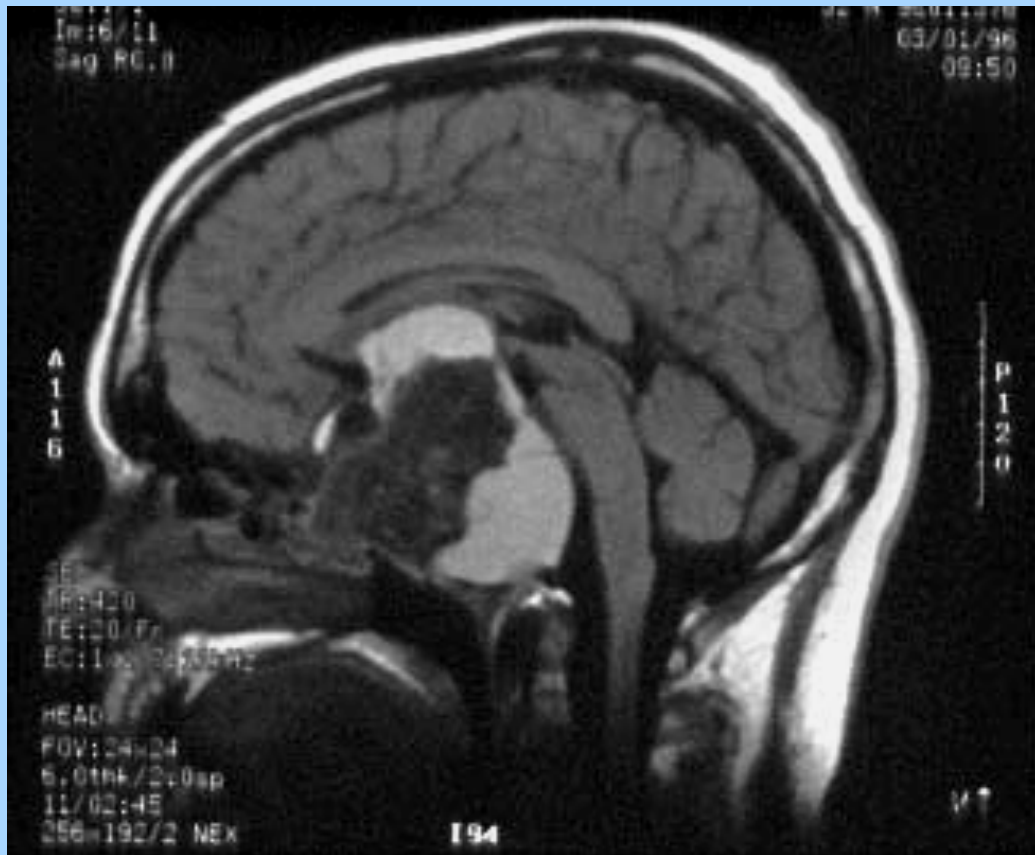
target volume

cystic enlargement

image guidance

Craniopharyngioma management

Target volume



Craniopharyngioma management

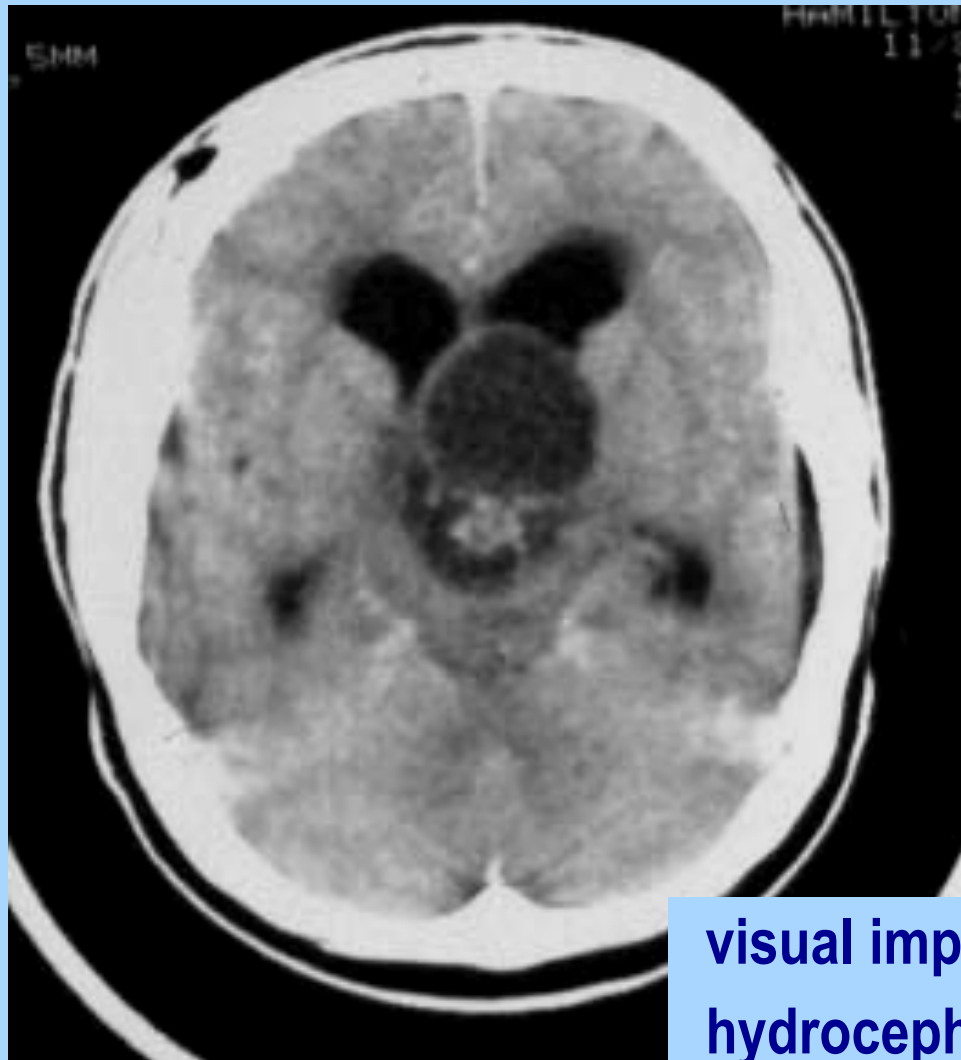
Practical issues

target volume

cystic enlargement

image guidance

Craniopharyngioma management



visual impairment
hydrocephalus

Craniopharyngioma management

Practical issues

target volume

cystic enlargement

image guidance

Craniopharyngioma management

technical aspects of
cranial RT

RT & SRT in benign
brain tumours

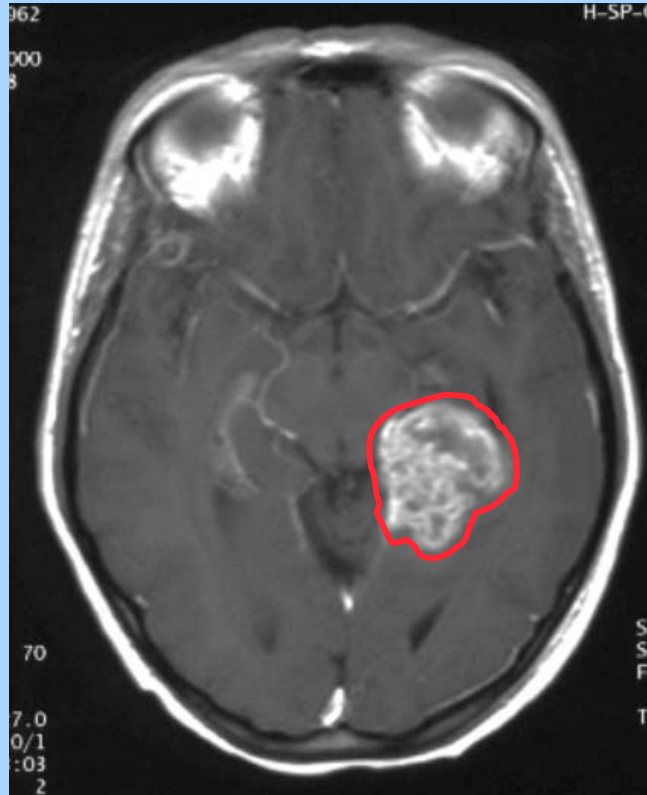
**RT & SRT in malignant
brain tumours**

outcome of SRT

Radiotherapy for primary brain tumours

Defining the treatment volume

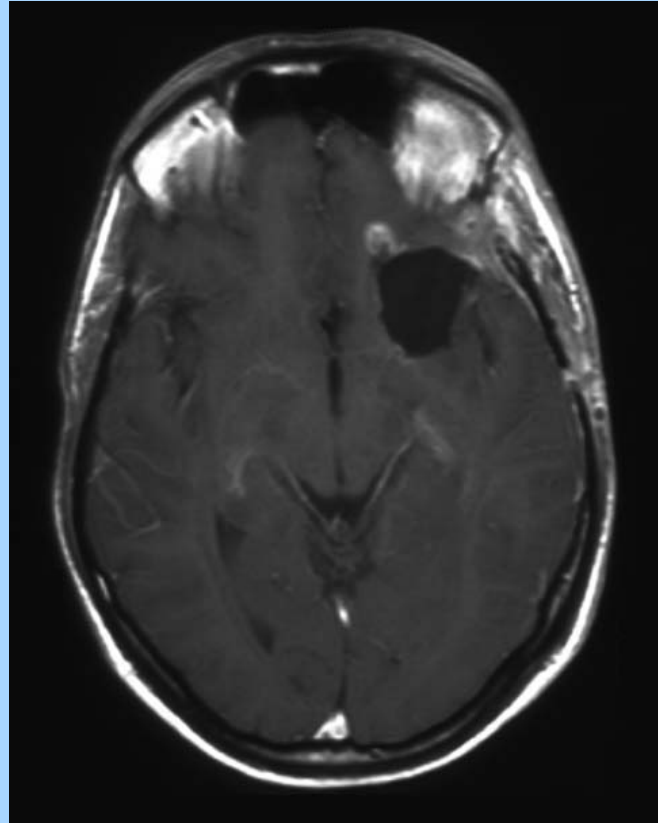
GTV



Radiotherapy in high grade glioma

Defining the treatment volume

GTV

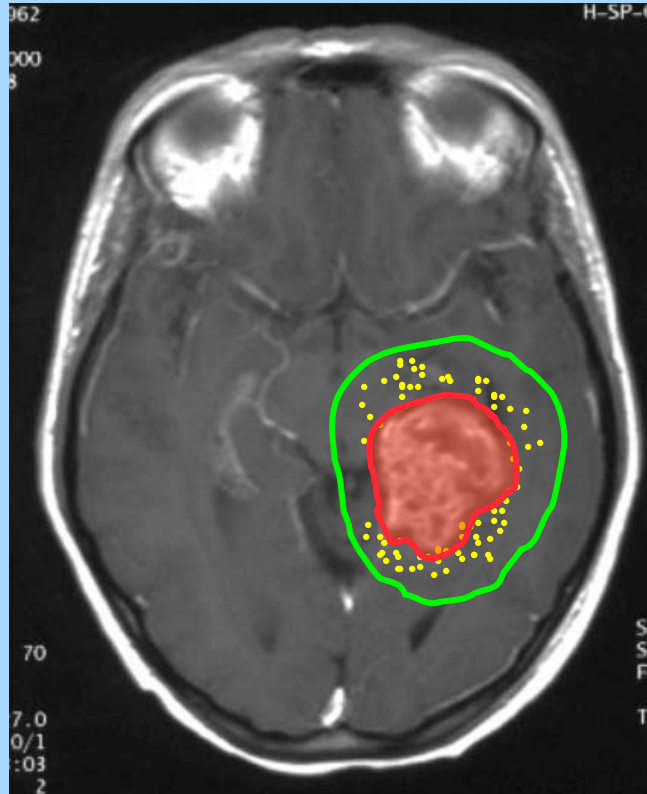


Radiotherapy in high grade glioma

Defining the treatment volume

GTV

CTV



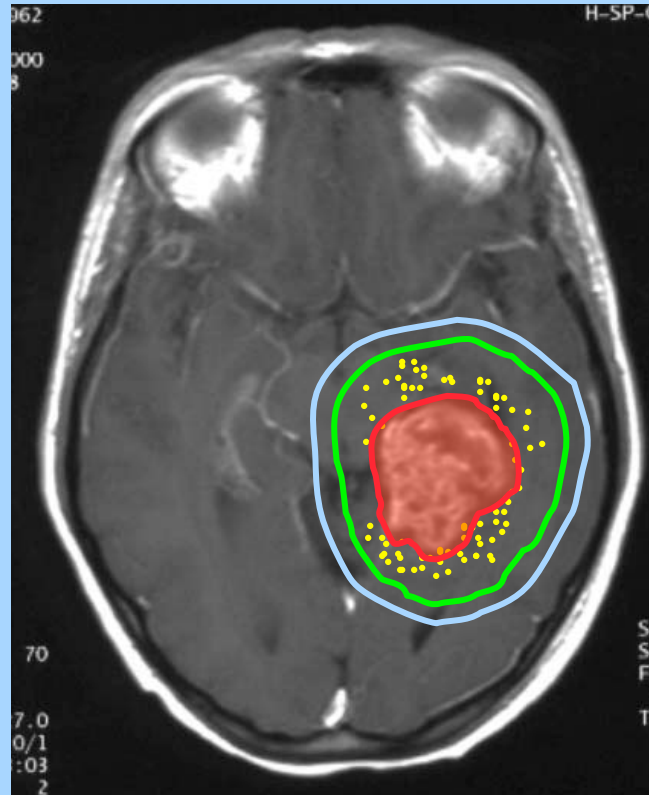
Radiotherapy in high grade glioma

Defining the treatment volume

GTV

CTV

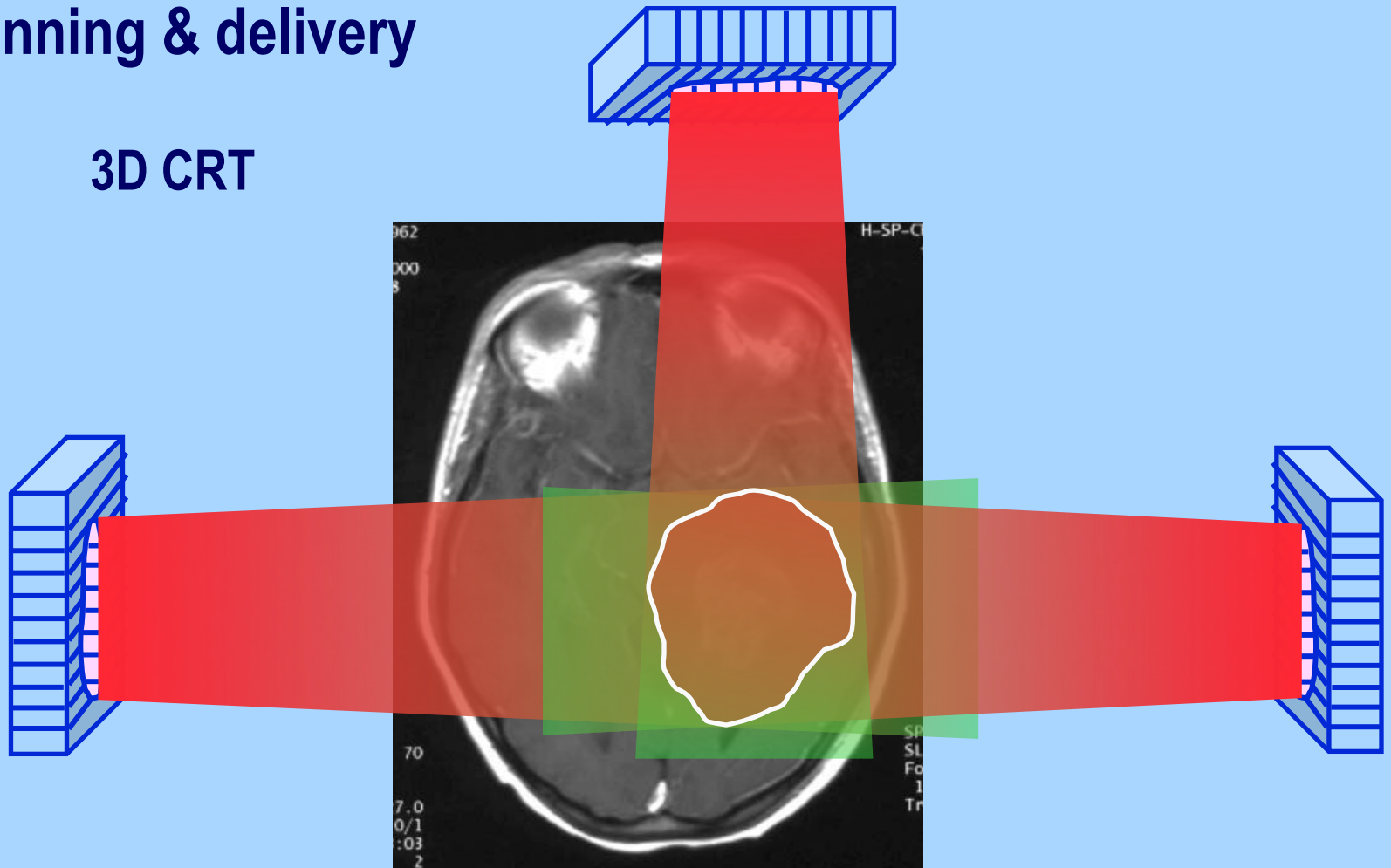
PTV



Radiotherapy in high grade glioma

Planning & delivery

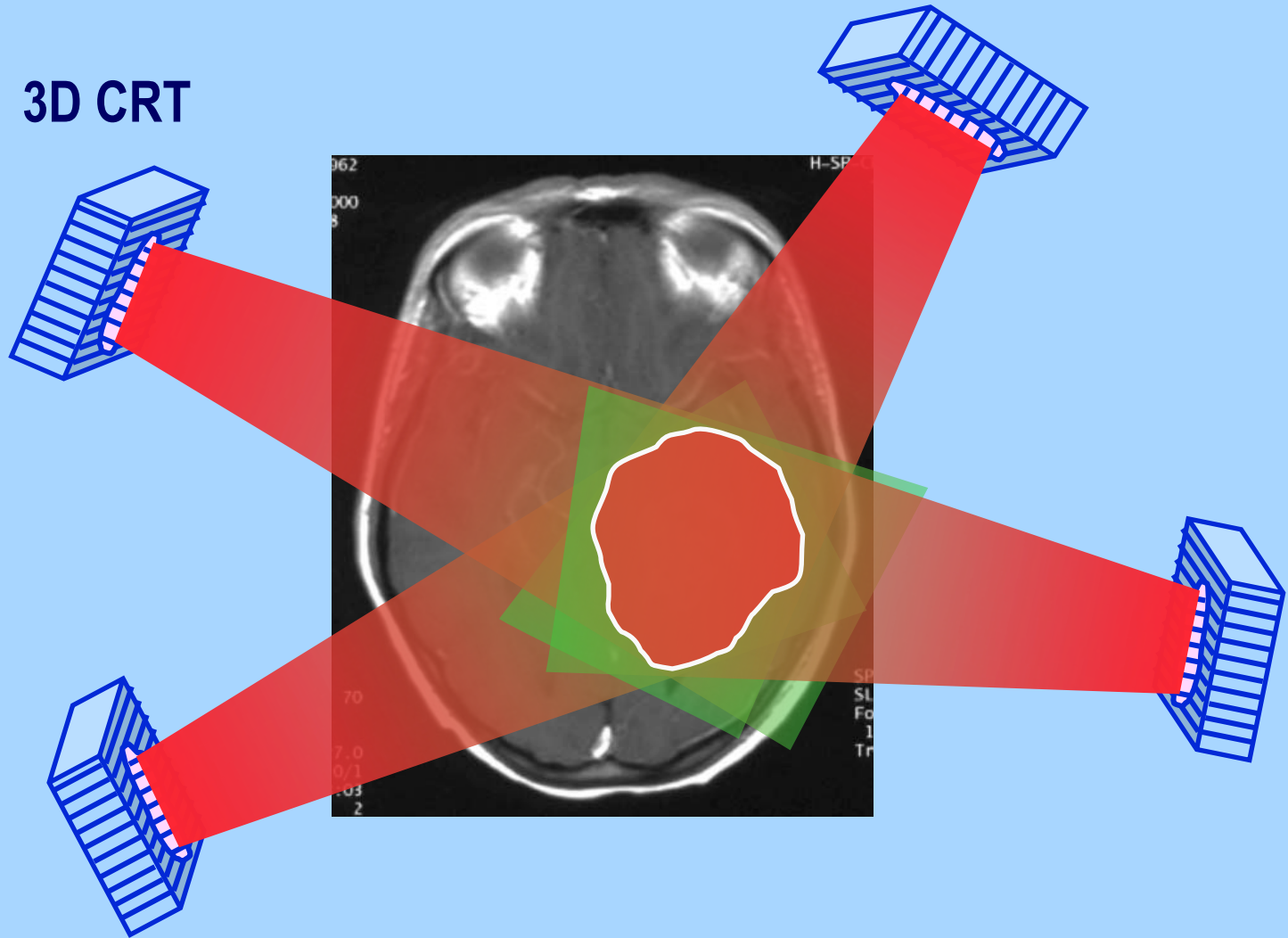
3D CRT



Radiotherapy in high grade glioma

Planning & delivery

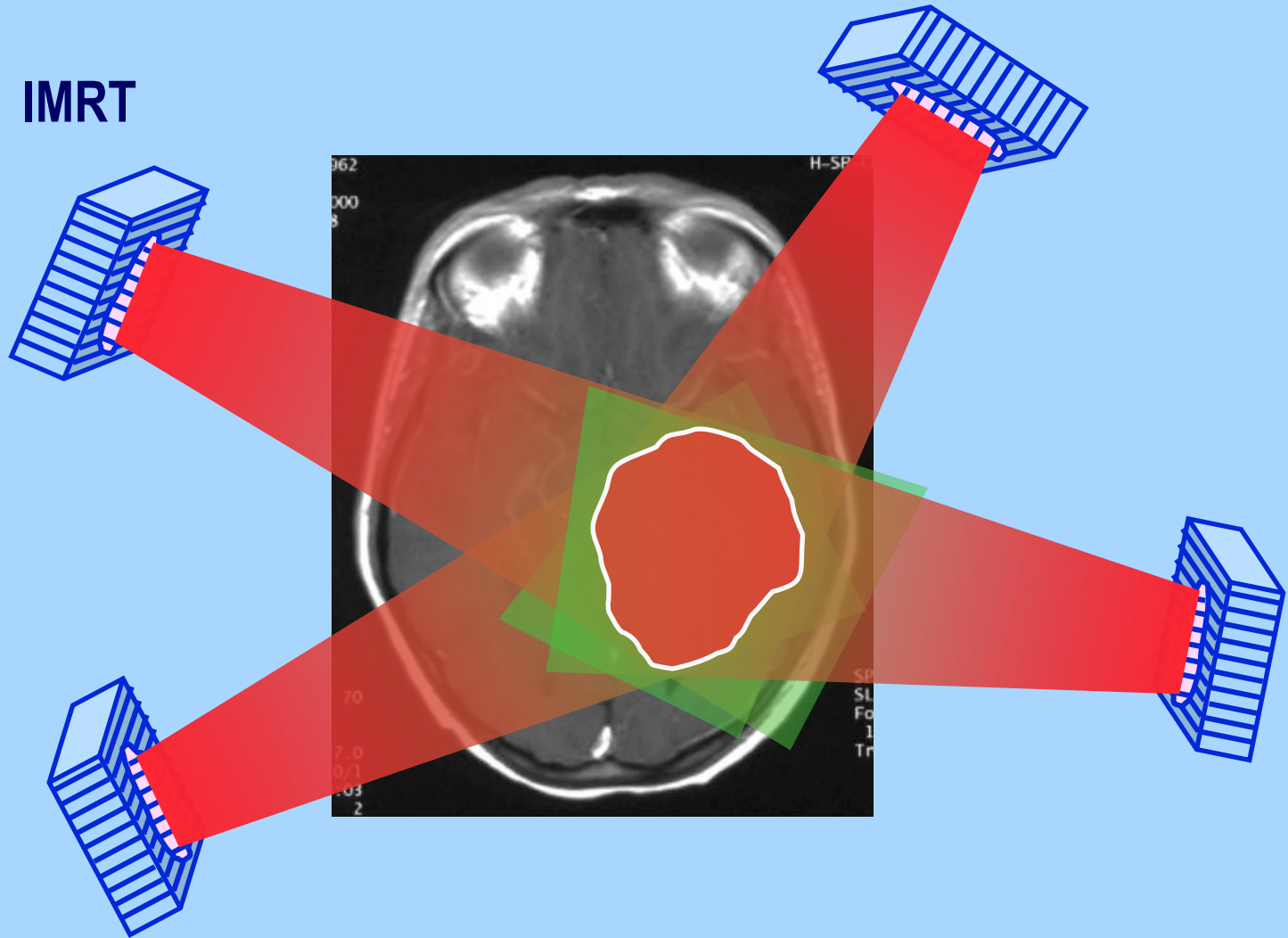
3D CRT



Radiotherapy in high grade glioma

Planning & delivery

IMRT



Radiotherapy in high grade glioma

static/dynamic IMRT

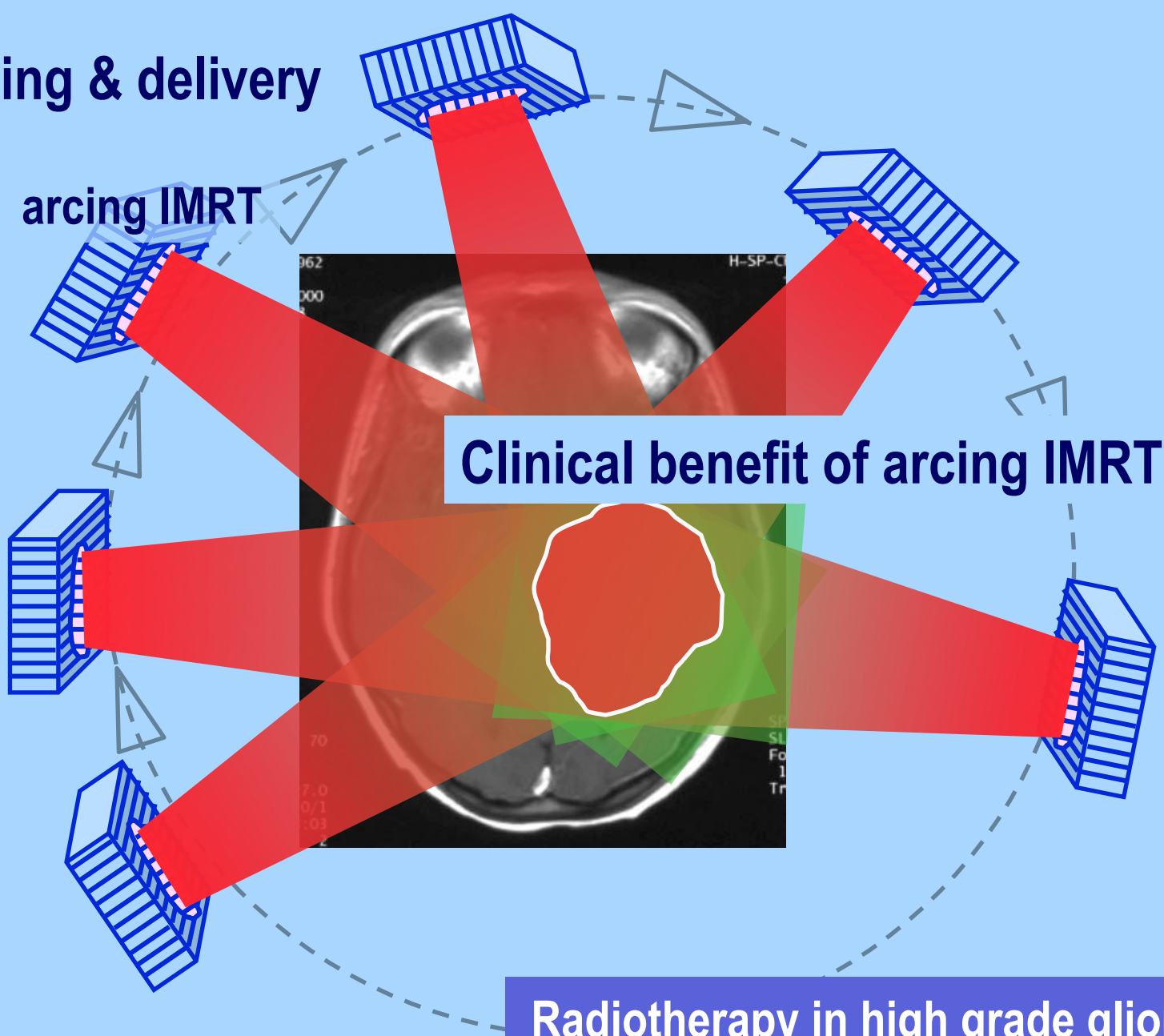
Planning & delivery

arcIMRT

Clinical benefit of arcIMRT?

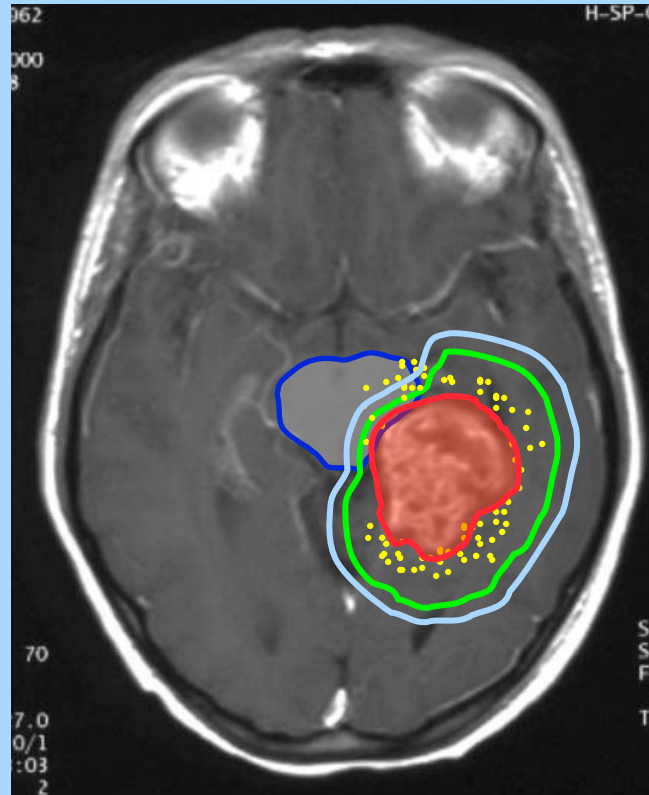
Radiotherapy in high grade glioma

RapidArc®/VMAT®/Tomotherapy®



Specific normal tissue avoidance

(arcing) IMRT

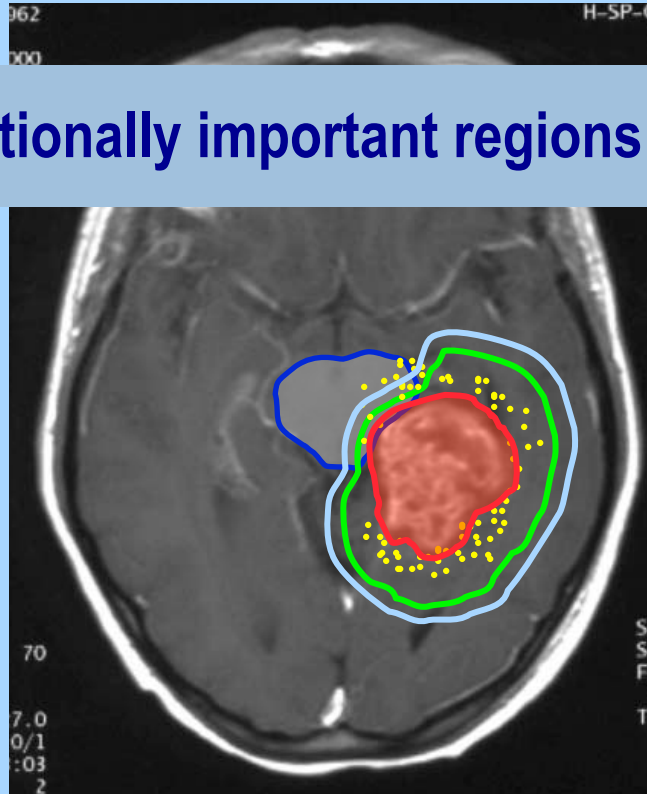


Radiotherapy in high grade glioma

Specific normal tissue avoidance

(arcing) IMRT

avoidance of functionally important regions

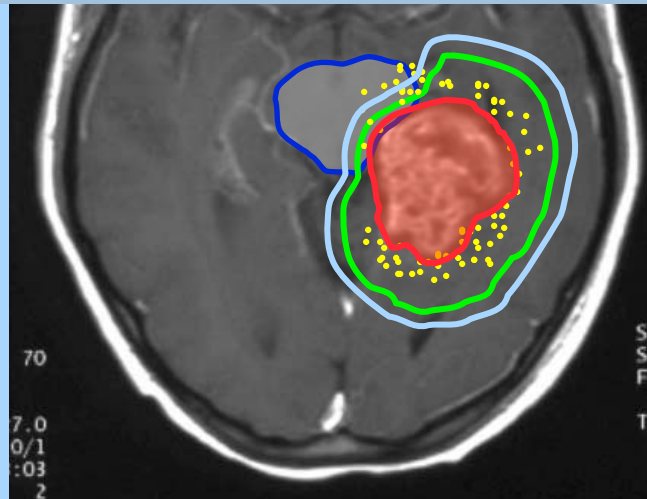


Radiotherapy in high grade glioma

Specific normal tissue avoidance

(arcing) IMRT

avoidance of functionally important regions
with defined toxicity following conventional dose fractionation

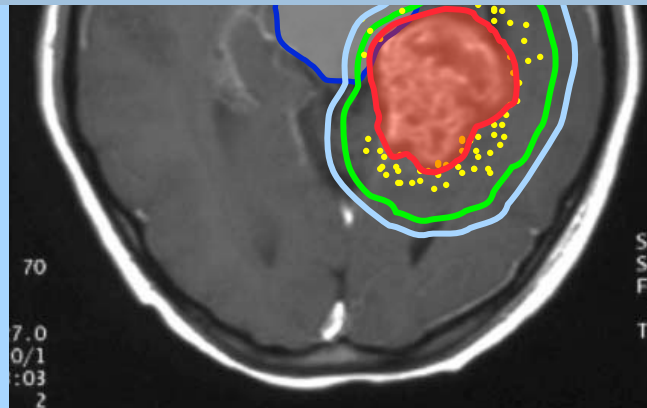


Radiotherapy in high grade glioma

Specific normal tissue avoidance

(arcing) IMRT

avoidance of functionally important regions
with defined toxicity following conventional dose fractionation
of clinical significance



Radiotherapy in high grade glioma

Specific normal tissue avoidance

dose limits

OAR	objective
brainstem	$D \leq 54\text{Gy}$, $1\text{-}10\text{cm}^3 < 59\text{Gy}$ (periph)
chiasm	$D_{\text{max}} < 55\text{Gy}$
cochlea	ideally one side $< 45\text{Gy}$
eyes - macula	$< 45\text{Gy}$
eyes - lens	ideally $< 6\text{Gy}$ max 10Gy
lacrimal gland	$D_{\text{max}} < 40\text{Gy}$
optic nerves	$D_{\text{max}} \leq 54\text{Gy}$, $D_{\text{max}} < 55\text{Gy}$
pituitary	$D_{\text{max}} < 50\text{Gy}$

Suggested dose limits in glioblastoma radiotherapy

Specific normal tissue avoidance

dose limits

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Suggested dose limits in glioblastoma radiotherapy

Specific normal tissue avoidance

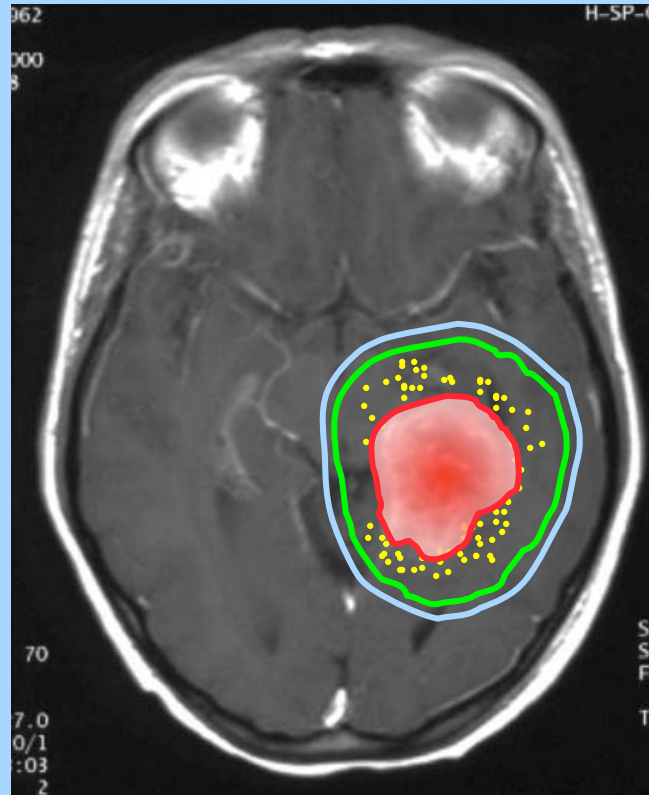
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Suggested dose limits in glioblastoma radiotherapy

Target & normal tissue dose gradient

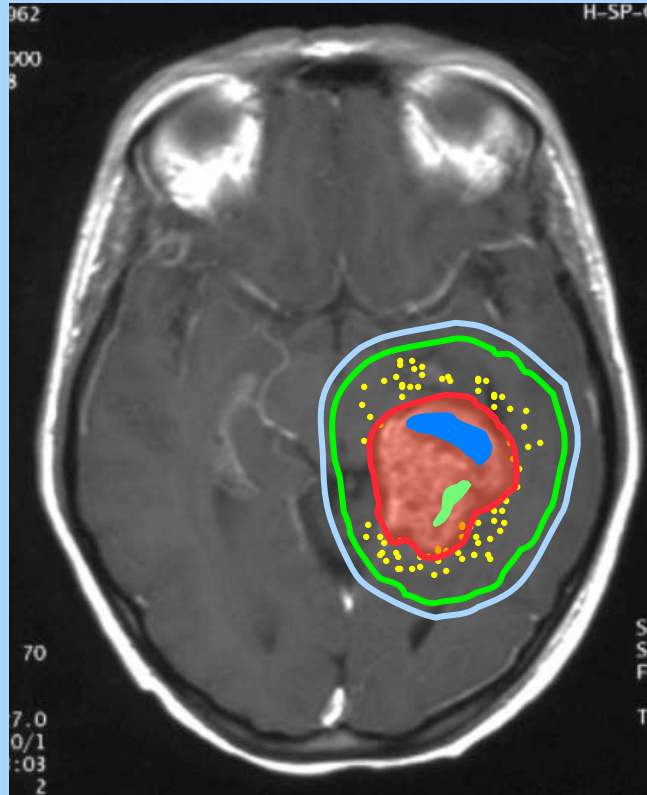
(arcing) IMRT



Radiotherapy in high grade glioma

Target & normal tissue dose gradient - dose painting

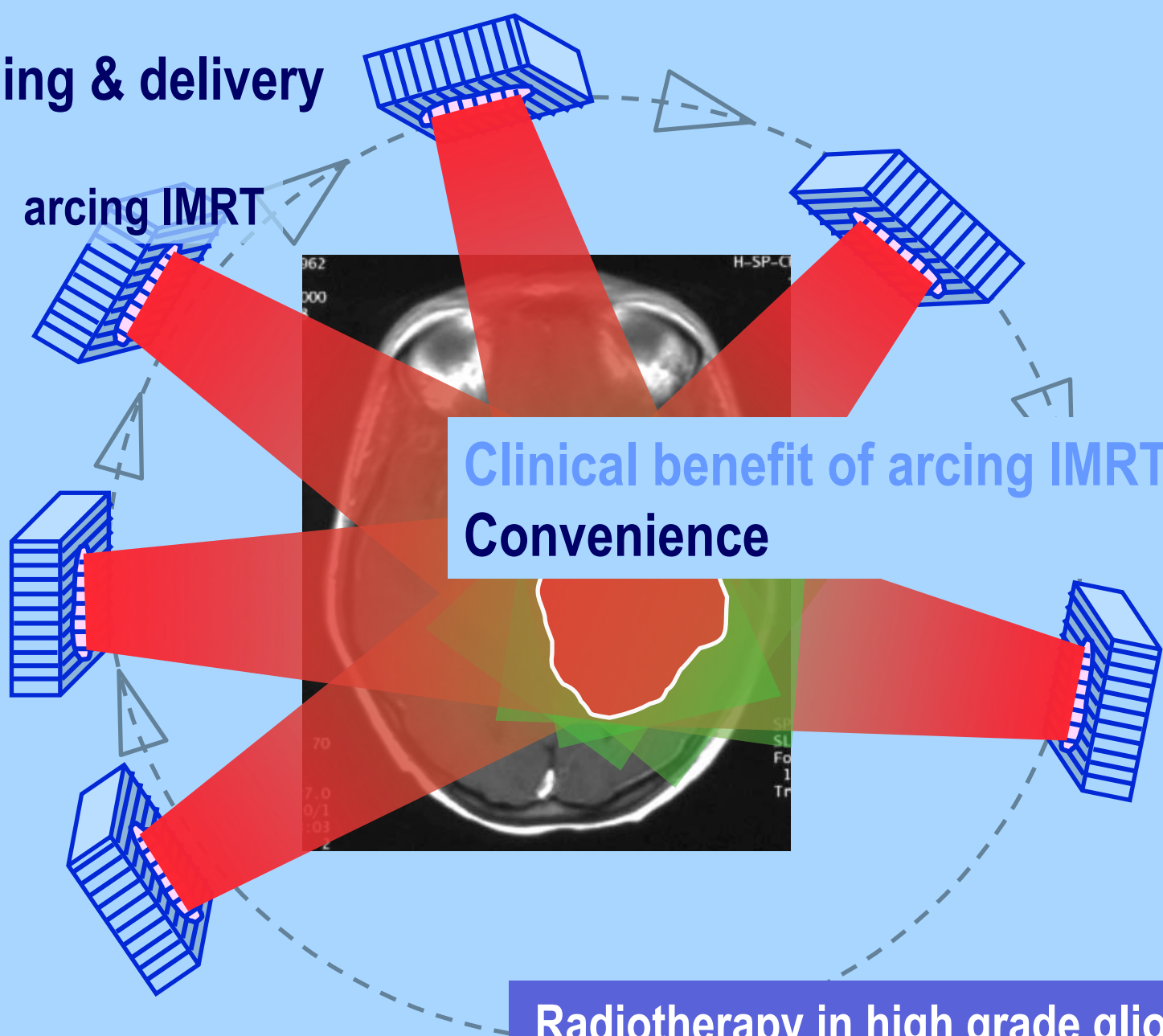
(arcing) IMRT



Radiotherapy in high grade glioma

Planning & delivery

arcIMRT



Radiotherapy in high grade glioma

RapidArc®/VMAT®/Tomotherapy®

**technical aspects of
cranial RT**

**RT & SRT in benign
brain tumours**

**RT & SRT in malignant
brain tumours**

outcome of SRT

Radiotherapy for primary brain tumours

Radiotherapy in the management of benign and malignant primary brain tumours

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