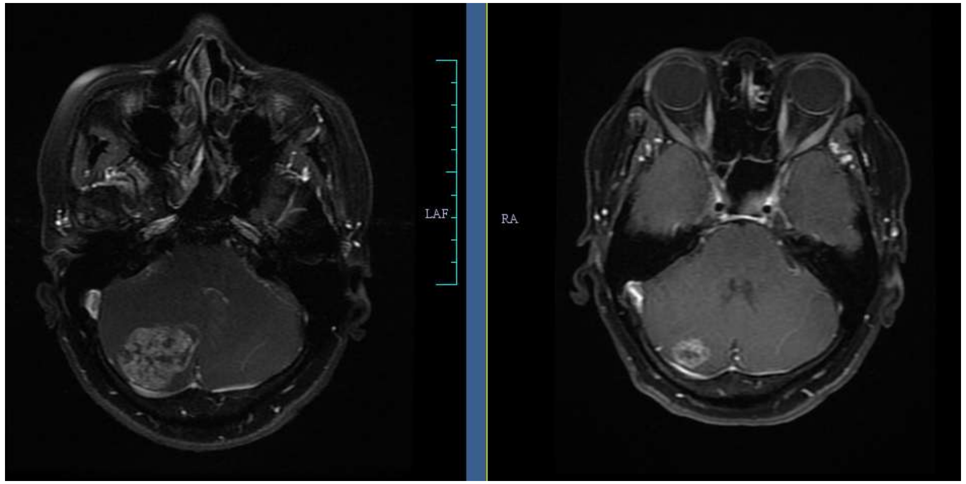


Brain Radiosurgery

Prof Debnarayan Dutta, MD

Prof & Head, Radiation Oncology

Amrita Institute of Medical Sciences, Kochi

Amrita Institute Radiosurgery: Presentation

35-40 patients / month
450-500 patients / year

60% Intracranial

- 50% are benign brain tumours
- 50% brain metastasis

50% Extracranial

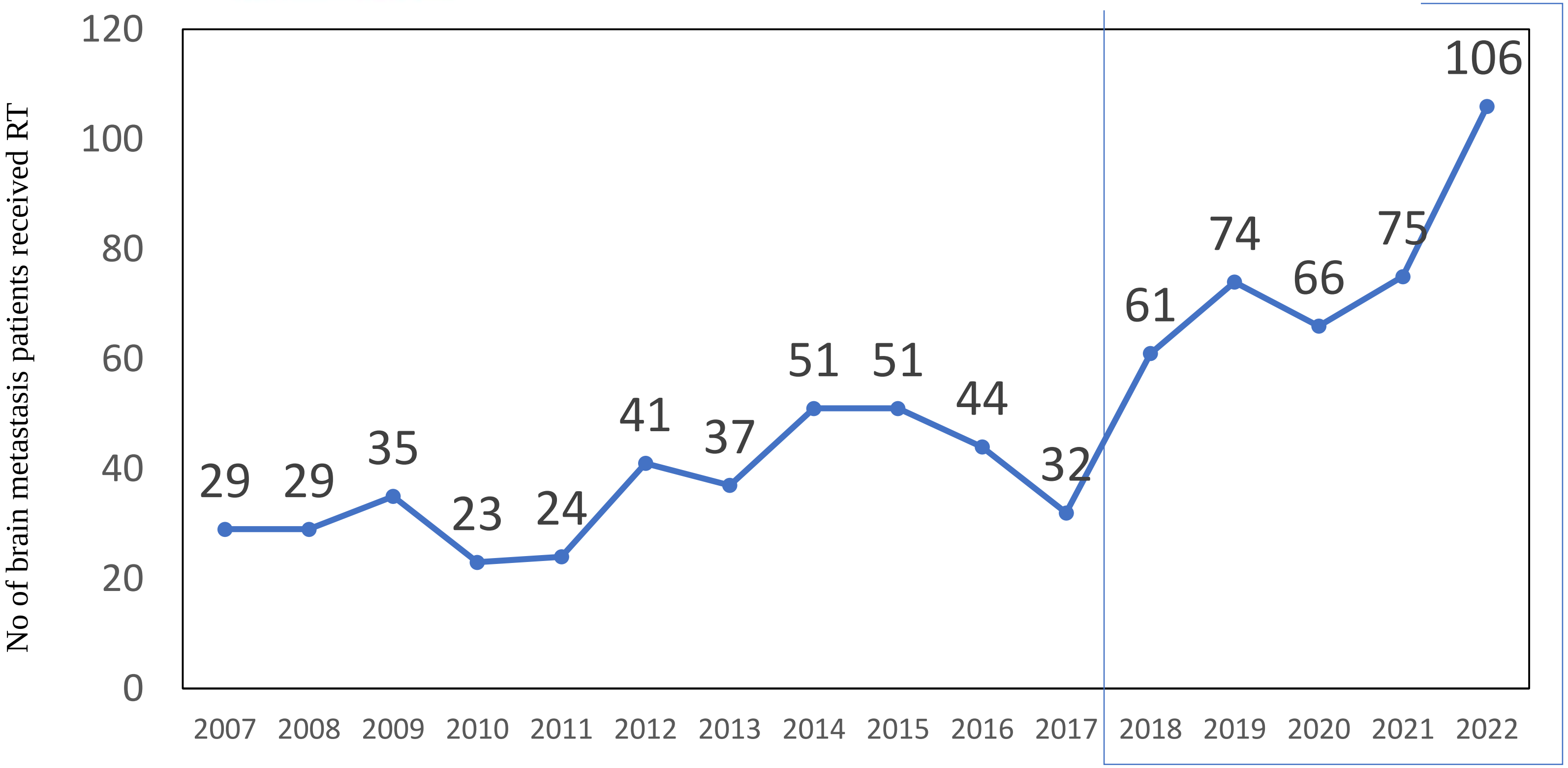
- 30% HCC
- 20% Oligo metastasis
- 10% Other extra-cranial
    - 3% Prostate cancer
    - 5% lung primary
    - 2% Mics (eye, RCC etc)

CyberKnife case	**1352**
Intracranial	769 (59%)
Brain metastasis	338 (25%)
Benign brain tumours	420
Meningioma	112
Acustic schwannoma	150
AVM	108
Glomus jugulare	35
Extra-cranial	583 (41%)
HCC	226
Lung	29
Prostate	28
Extra-cranial mets	225

In any radiosurgery program 60-70% of cases are brain radiosurgery

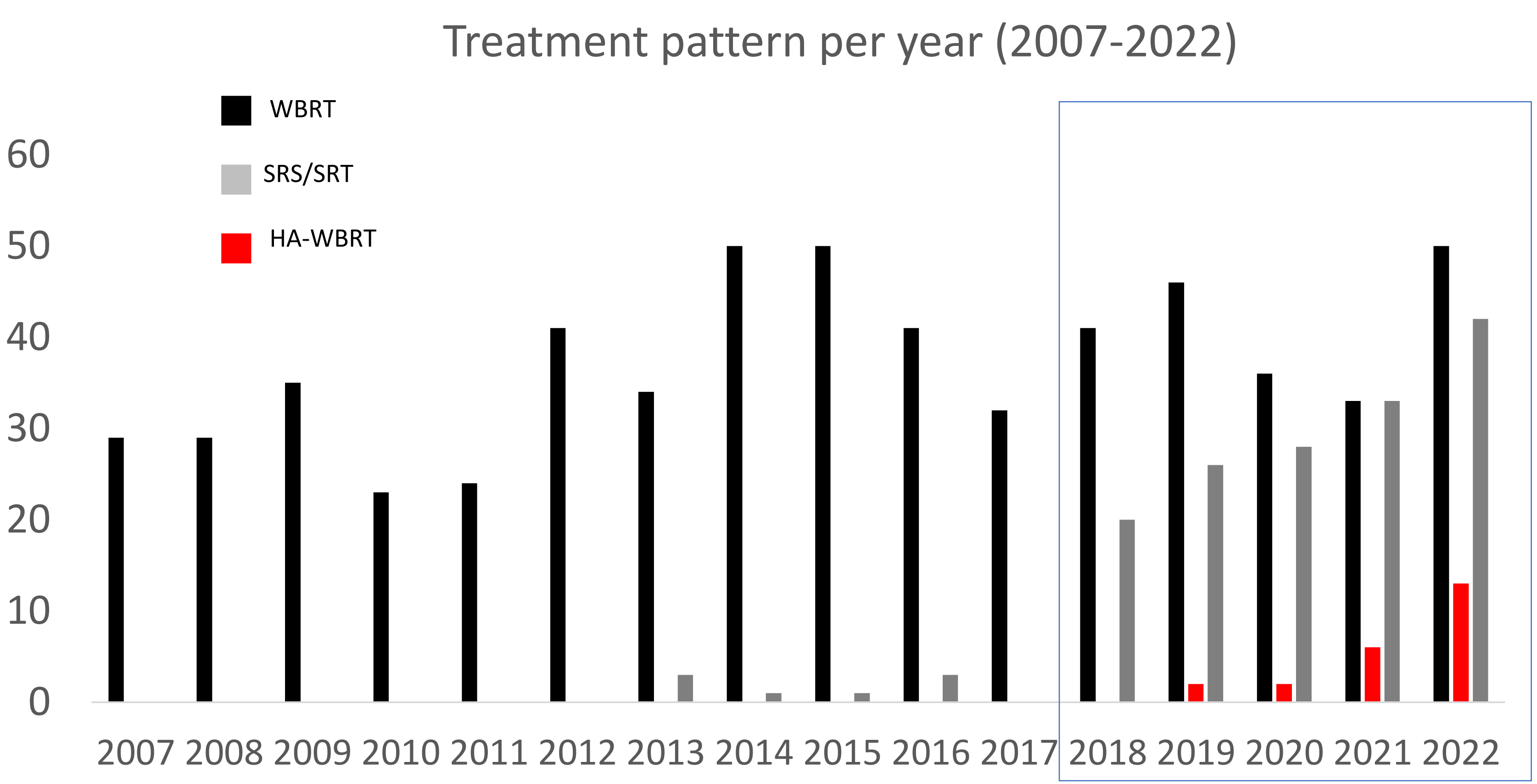
Audit of Presentation, Primary Site, and Pattern of Treatment in 778 Indian Patients with Brain Metastasis in 15 Years (2007–2022)

Debnarayan Dutta*, Haripriya P Surendran[1]*, Sruthi Kalavagunta, Ajay Sasidharan, Narmadha M P[1]



- Audit of 730 brain metastasis patient treated at Amrita Institute
- Yr-2007-2022
- Brain metastasis pts treated with RT increasing over the years

Dutta et al, Neurol India 2023



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total Ca in RT	-	1368	1756	1762	1831	1683	1791	2182	1971	1748	1682	1933	1893	1659	1767	1960
Incidence of BM (%)	-	2.1	1.65	1.98	1.91	2.43	2.06	2.33	2.58	2.51	1.90	3.15	3.9	3.97	4.24	5.40
WBRT	29	29	35	23	24	41	34	50	50	41	32	41	46	36	33	50
HA-WBRT	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6	13
SRS	0	0	0	0	0	0	3	1	1	3	0	20	26	28	33	42

Dutta et al, Neurol India 2023

Brain Radiosurgery Indications

Benign brain tumours:
1. Acustic schwannoma
2. Glomus Jugulare
3. Meningioma
4. Pituitary tumour

Usually need lower dose (12-15Gy)
Dose escalation do not help
‘Lack of progression’ is considered response
Need years for radiological response
Long term survival
Toxicity is of paramount importance

Vascular lesions:
1. AVM
2. Haemangiomas
3. Cavernomas

Usually need Higher dose (18-20Gy)
Obliteration need time. Usually 2-3 years
Risk of bleed persists during ‘latent’ period
Complete obliteration is considered response

Brain Radiosurgery Indications

Malignant lesions: 1. Brain metastasis 2. Recurrent glioma	Usually need higher dose (20-24Gy). Dose escalation helps Survival 1-2 years Radiological Response considered ‘effective’ treatment Response assessment at 3 months
Functional Indications: 1. Trigeminal neuralgia 2. Epilepsy 3. Movement disorders	Usually need high dose (150-170Gy) Long term survival Toxicity is paramount importance Symptom free period and ‘medicine free period’ considered response

Approach, response assessment and duration of follow up depends upon the indications

SRS ?

Single fraction RT for brain lesions. Mostly coined for GammaKnife. Since 1960

SBRT ?

Multiple fraction treatment for extra-cranial lesions. Mostly for LA based treatment. Since 1980

SABR ?

RT dose >6Gy, Single or multiple session for brain & extra-cranial site. Since 2011

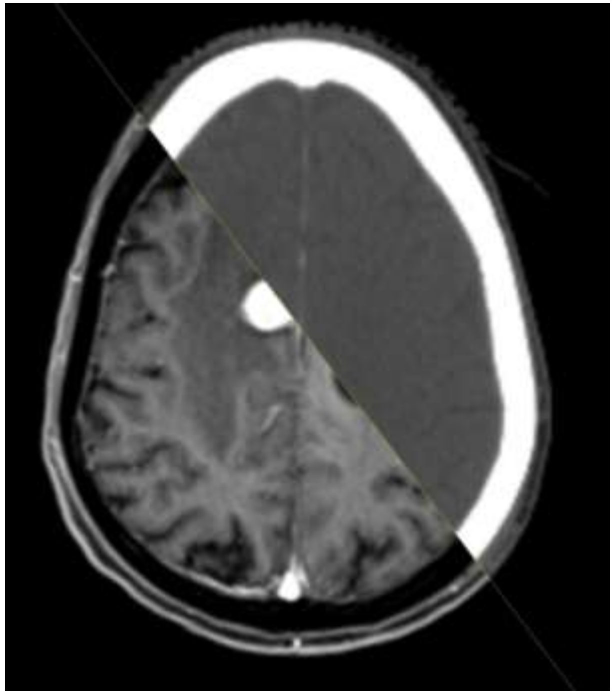
Modern Radiosurgery: ‘stereotaxy’ less & image guidance more

- Modern radiosurgery have evolved in last few decades
- ‘Stereotaxy’ has become less important
- Image guidance is critical for radiosurgery
- Role of stereotactic frame, rigid immobilization & stereotactic localization have reduced

- Imaging has become critical for contouring
- ‘real time’ imaging is used for ‘guidance’ instead of stereotactic guidance

- ‘Stereotactic radiosurgery’ terminology have less relevant & image guided radiosurgery is the new terminology

- Planning, dose distribution & dosage schedule, radiobiology, response assessment is important in modern radiosurgery
- Role of trained radiation oncologist in high dose radiation has become more important



Brain Radiosurgery: Work flow

Case selection

Immobilization

CT Simulation

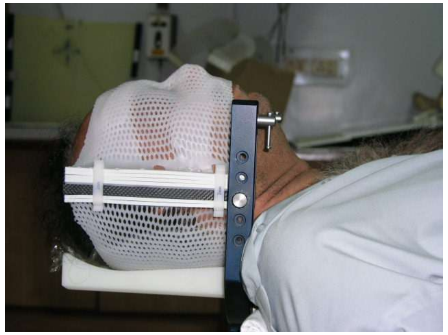
Image fusion

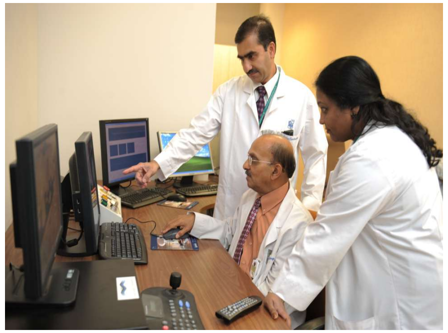
Contouring

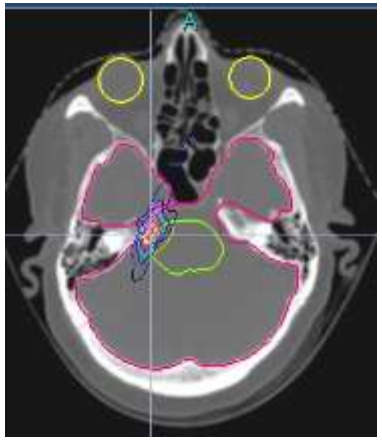
Planning

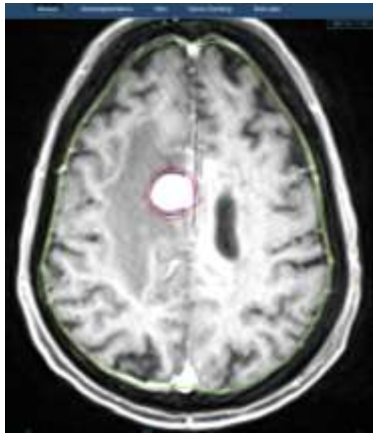
Treatment delivery

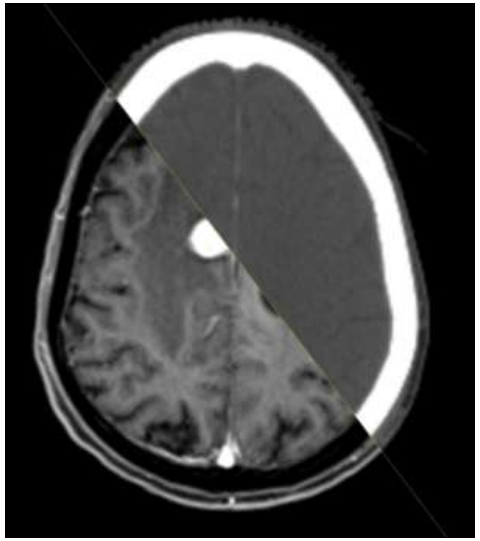
Response assessment & follow up











Radiosurgery: tools

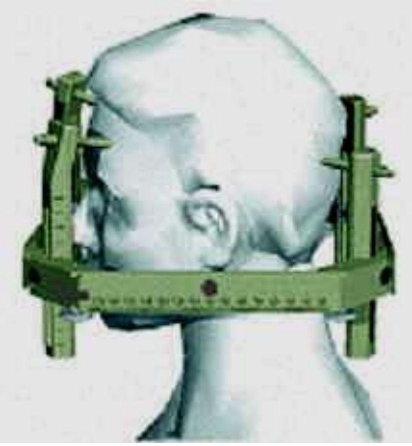
Gamma-Knife

LA based SRS Systems

BrainLAB
Novalis
Trilogy
Tomotherapy

CyberKnife

Gamma knife



- Gamma-knife: 201 Cobalt source
- Only for **intracranial** lesions
- Rigid/ **fixed frame** required
- **Single fraction** treatment

BrainLAB

Micro MLCs

Rigid frame / mask

BrainLAB planning System

Both SRS & SCRT

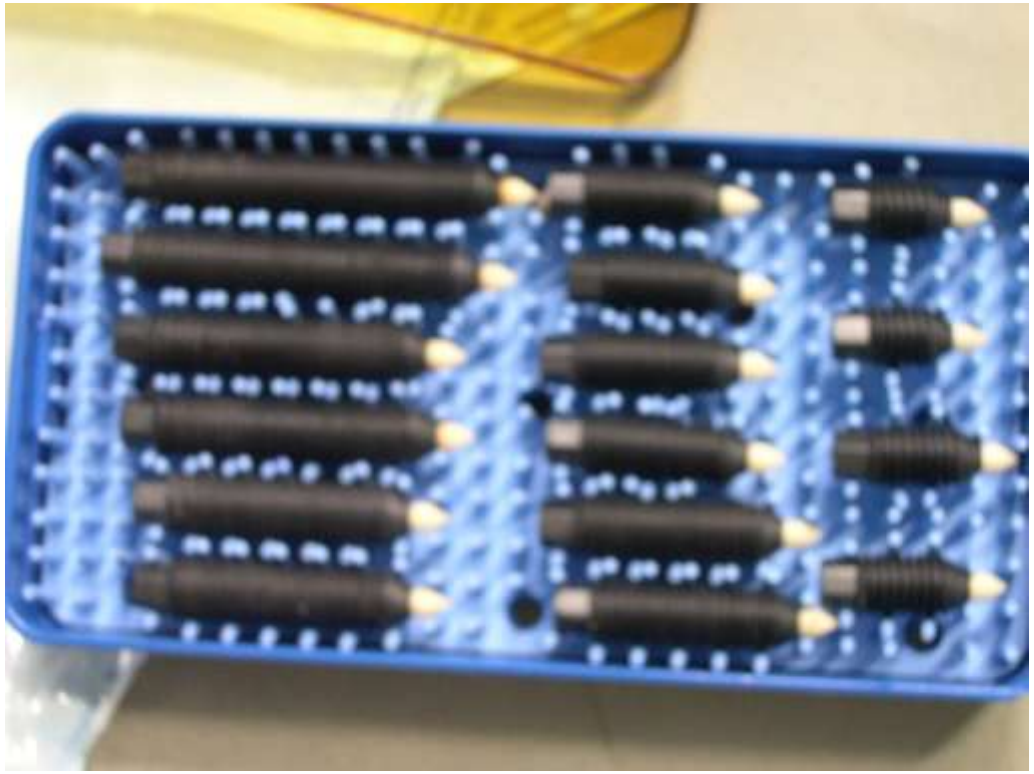
For brain lesions

BrainLAB - SRS

BrainLAB - SRS

BrainLAB - SRS

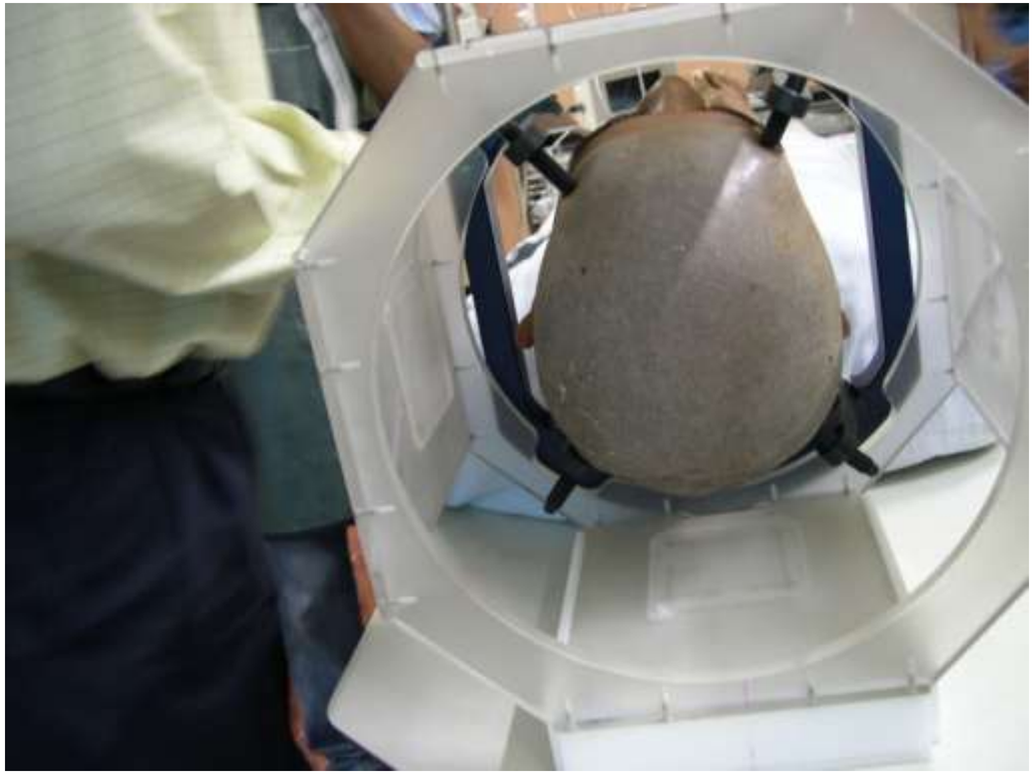
BrainLAB - SRS



BrainLAB - SRS

BrainLAB - SRS

BrainLAB - SRS



BrainLAB - SRS

BrainLAB - SRS

BrainLAB - SRS

BrainLAB - SRS

BrainLAB - SRS

BrainLAB - SRS

BrainLAB - SRS

BrainLAB SCRT frame

QA: Beam's eye view & LUTZ's test

Iso-centric accuracy: LUTZ test

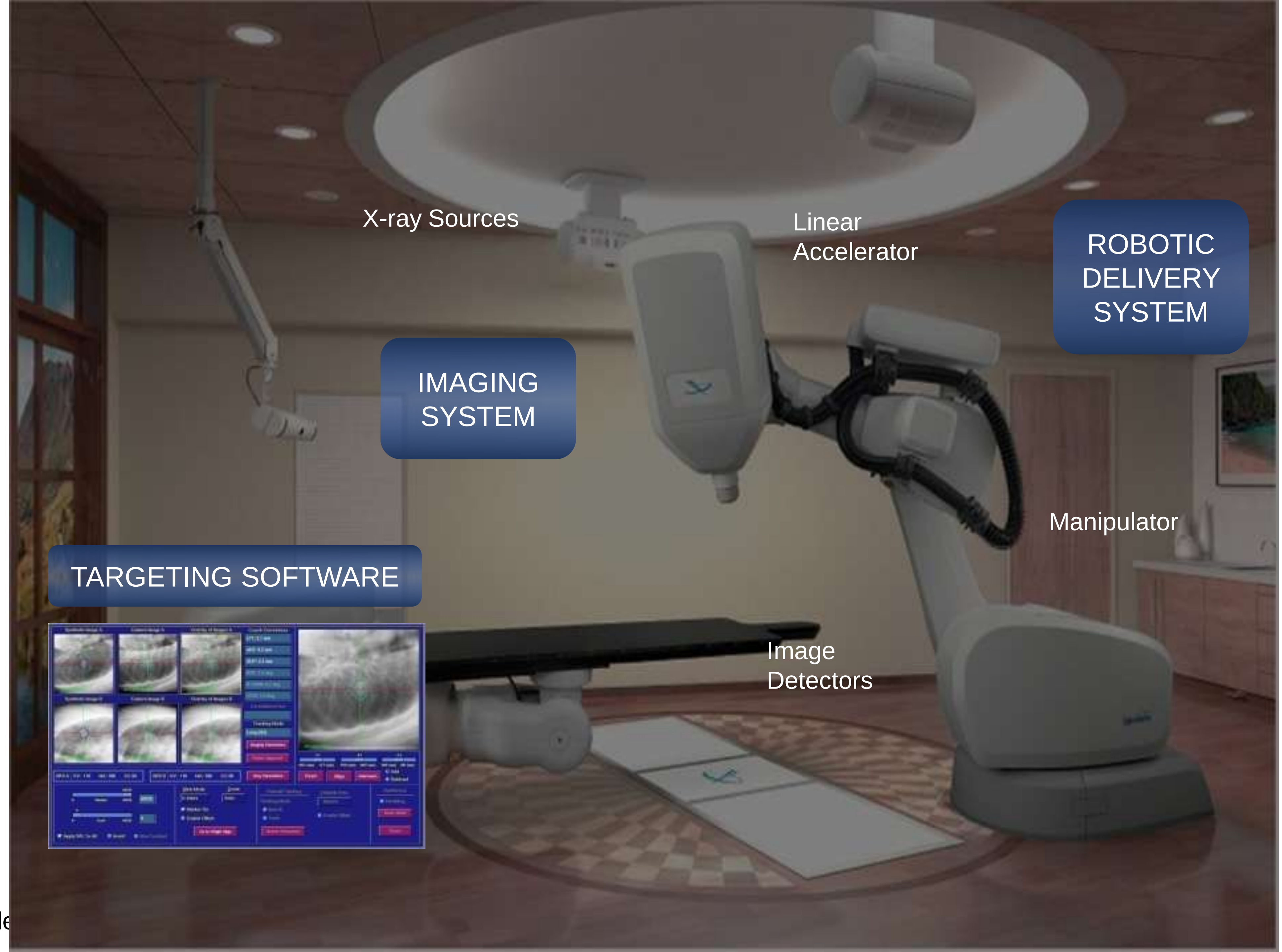
Beam's position check

Robotic Radiosurgery (CyberKnife)

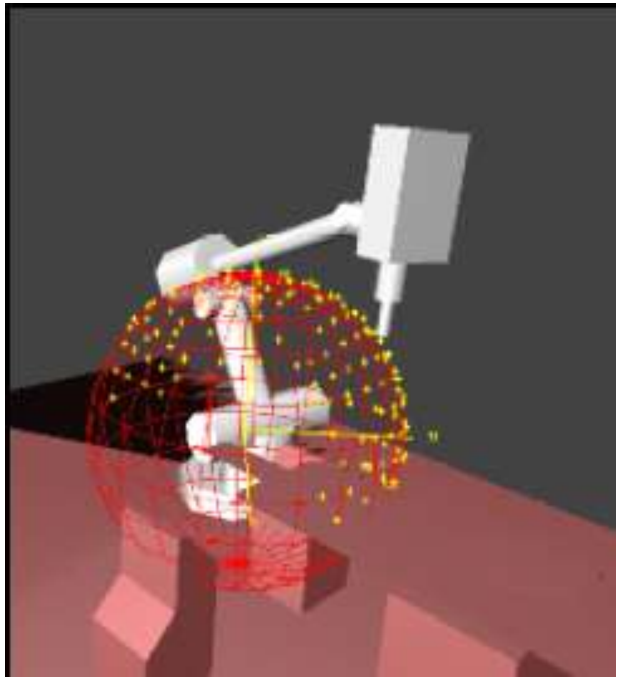
Highly precise RT delivery system
- Respiratory tracking
- Fiducial based tracking system
- Intra-fraction motion correction
- Uncomparable dose distribution
- X-ray based image verification

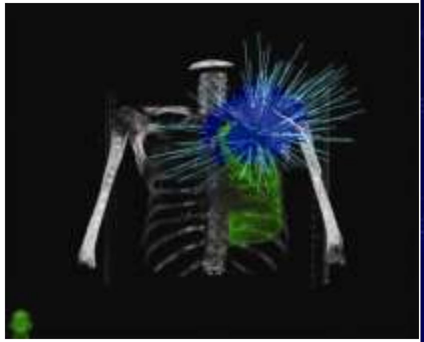
Hypofractionated RT
- High dose short course RT
- Higher BED delivered to target

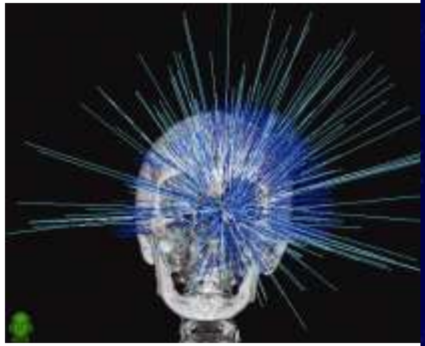
Ideal for moving targets

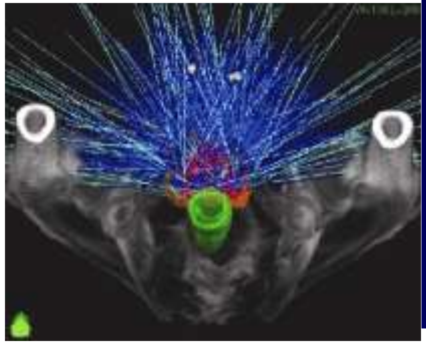

X-ray Sources
Linear Accelerator
ROBOTIC DELIVERY SYSTEM
IMAGING SYSTEM
Manipulator
TARGETING SOFTWARE
Image Detectors

Unique features of Cyberknife: Non-coplanar field arrangement



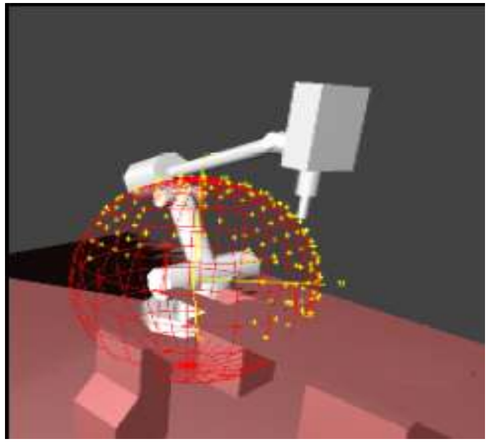






- 6 MV accelerator
- 12 interchangeable circular collimators
- At an SSD of 80cm, collimators provide a beam diameter from 5 to 60 mm
- SSD can be varied from 65 to 100 cm
- Radiation is delivered at a discrete set of linac positions (called nodes).
- A typical treatment plan will use 110 nodes distributed approximately uniformly over about one half of a sphere centered on the treatment site.

‘CyberKnife is an extension of Gamma-Knife’



CK & GK: Similarity

- Principles of ‘field arrangement’
- Dose distribution pattern
- Multiple isocentre
- Treatment principles
- Treatment delivery accuracy similar
- Delivered dose in single fractions
- Intra-cranial indications

Cyberknife Vs Gamma-Knife: Dissimilarity

	GK	CK	Comments
Immobilization device	Rigid frame	Orfit	CK has favorable orfit
RT source	Co60	6MV LA	GK need to replace sources every 5/6 yrs
Planning	No complex planning	Inverse planning	Favorable dosimetry in CK
Planning method	Simple	Complex	Even neurosurgeons can plan in GK
Isodose prescription	Usually 50%	Usually 80-95%	GK: more dose heterogeniety
Fractions	Single	May treat multiple fraction	Radiobiology favorable in CK
Tumour size	Only smaller lesions can be treated	Larger lesions also can be treated in fractionated schedule	Increased indications with CK
Energy source	Radiation	Electricity	GK can work with less electricity
Verification	Not possible	Possible	Even Intra-fraction movement can be corrected
Indications	Only brain lesions	Both extra & intra cranial	CK more economical

20Gy/1fraction
Prescription at 50% Isodose

20Gy/1fraction
Prescription at 95% Isodose

20Gy/1fraction

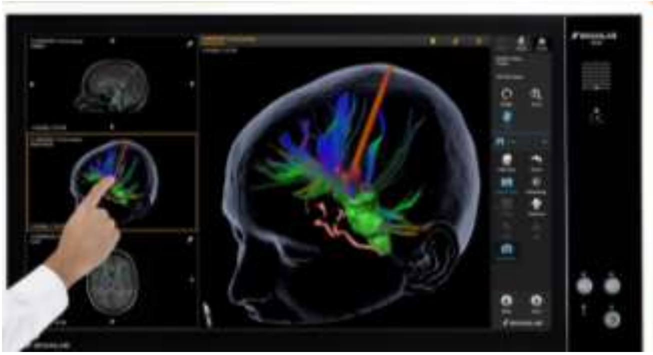
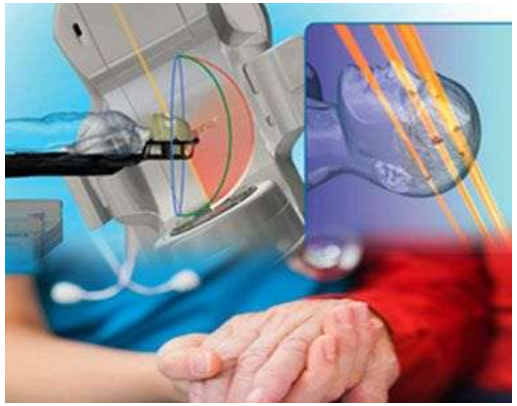
Comparison of high dose region

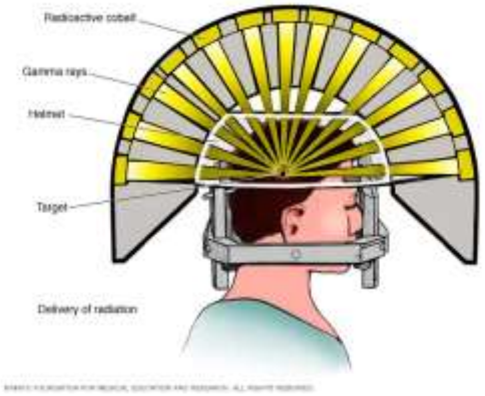
20Gy/1fraction
Comparison of low dose spill

	Name	Comp	Min (cGy)	Min r (cGy)	Mean (cGy)	Mean r (cGy)	Max (cGy)	Max r (cGy)	CI	CI r	nCI	nCI r	HI	HI r	Coverage (%)	Coverage r (%)
	PTV	Yes	1207	1925	2848	2045	4000	2105	1.14	1.08	1.19	1.13	2.00	1.05	96.35	95.83
	GTV	Yes	1593	1999	3198	2054	4000	2105	1.90	1.77	1.90	1.77	2.00	1.05	99.67	99.97
	*BRAINSTEM	No	5	7	23	55	256	228	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	WHOLE BRAIN	Yes	3	5	179	263	4000	2105	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Multiple iso-centre
Homogenous dose distribution

Planning & delivery in different systems



- **Dose prescription:**
  50% Vs 90%
- **Isocenter**
  Single Vs multiple
- **Dose homogeneity**
  Heterogenous Vs Homogenous
- **Low dose spillage**
  Higher low dose spill with prescription isodose
- **Treatment time**
  Higher treatment time with radiobiological effect
- **PTV margin**
  Dose prescription depending upon margin

Different radiobiological & clinical impact

Proposed Classification for SABR

- Extended boundary for the formation of planning target volume (PTV) is inconsistent in varied SABR technology
- E.gL Gamma-knife, Liner-accelerator, CyberKnife, and TomoTherapy system),
- Clinical efficacy and its side effects are quite variant.

Proposal for classification for SABR based on each equipment and technology:

- Gamma-knife-SABR (**G-SABR)**
- Liner-accelerator- SABR (L-SABR)
- CyberKnife-SABR (C-SABR)
- Tomo-SABR (T-SABR)
- Proton-SABR (P-SABR)

- High-dose rate brachytherapy SABT (H-SABT)
- Low dose rate brachytherapy: SABT (L-SABT),

Convenient for communication and comparison of the clinical outcomes among these technologies.

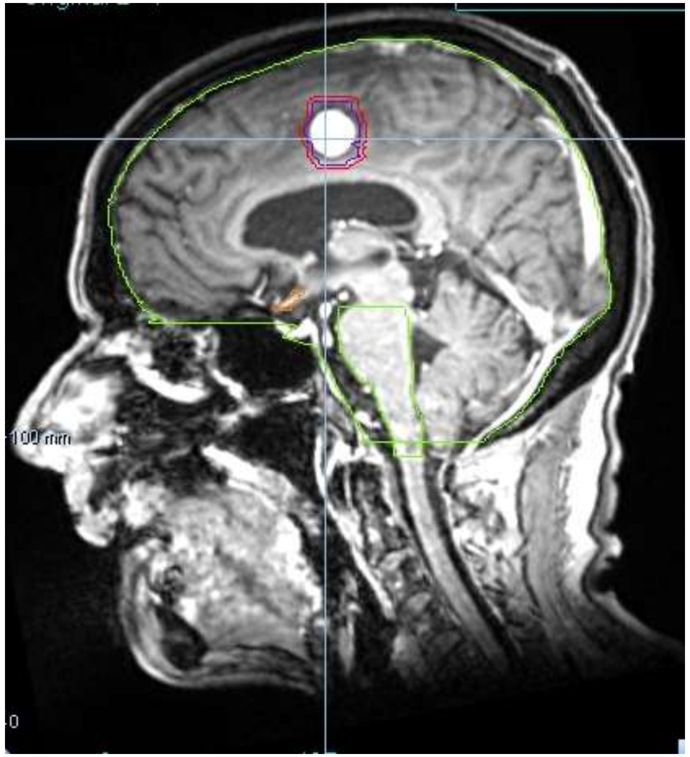
Contouring Principle

- In Radiosurgery, we treat ONLY ‘What is seen’ = GTV

- There is NO CTV = HIGHER risk of failure if not contoured

- SHARP dose fall off = MARGINAL miss risk high, if not contoured

- NO margin of error

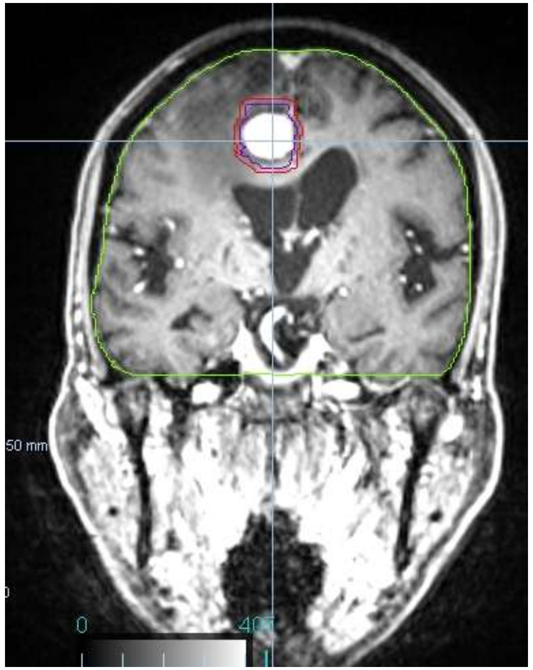


Contouring: Principles

How to improve imaging to have better contouring
Solutions

A) Improve CT scan imaging –

1. CT scan with proper contrast, slice thickness
2. CT at proper sequence, phase of respiration
3. CT scan image acquisition time, duration



B) Additional sequences / image modality –

1. MRI scan – T1 / T2/ Flair
2. PET scan

C) Functional imaging –

1. Biological imaging

CT scan: Slice spacing

Data are usually based on CT images:

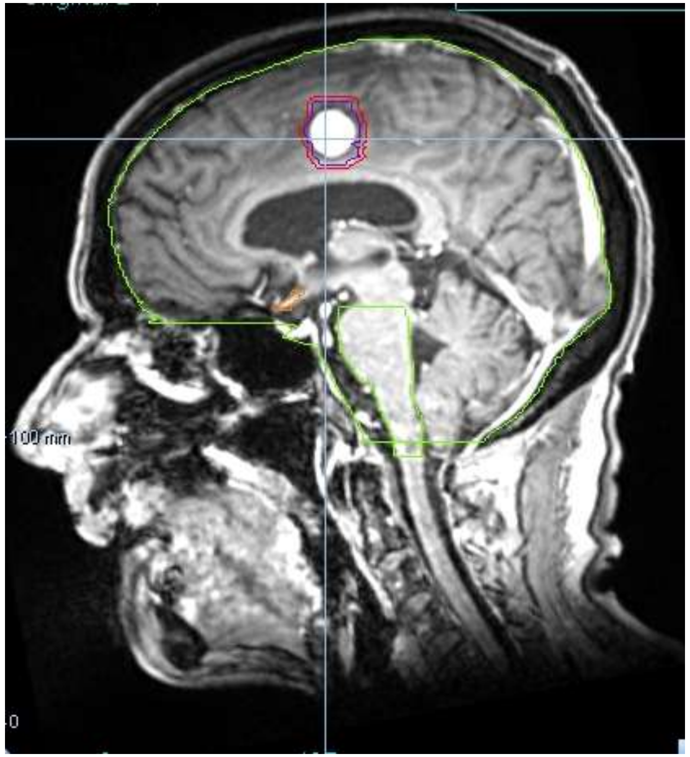
Suitable slice spacing?

0.5 - 1 cm for thorax

0.5 cm for pelvis

0.3 cm for head and neck.

0.1cm for Radiosurgery/SBRT



Radiosurgery slice thickness:

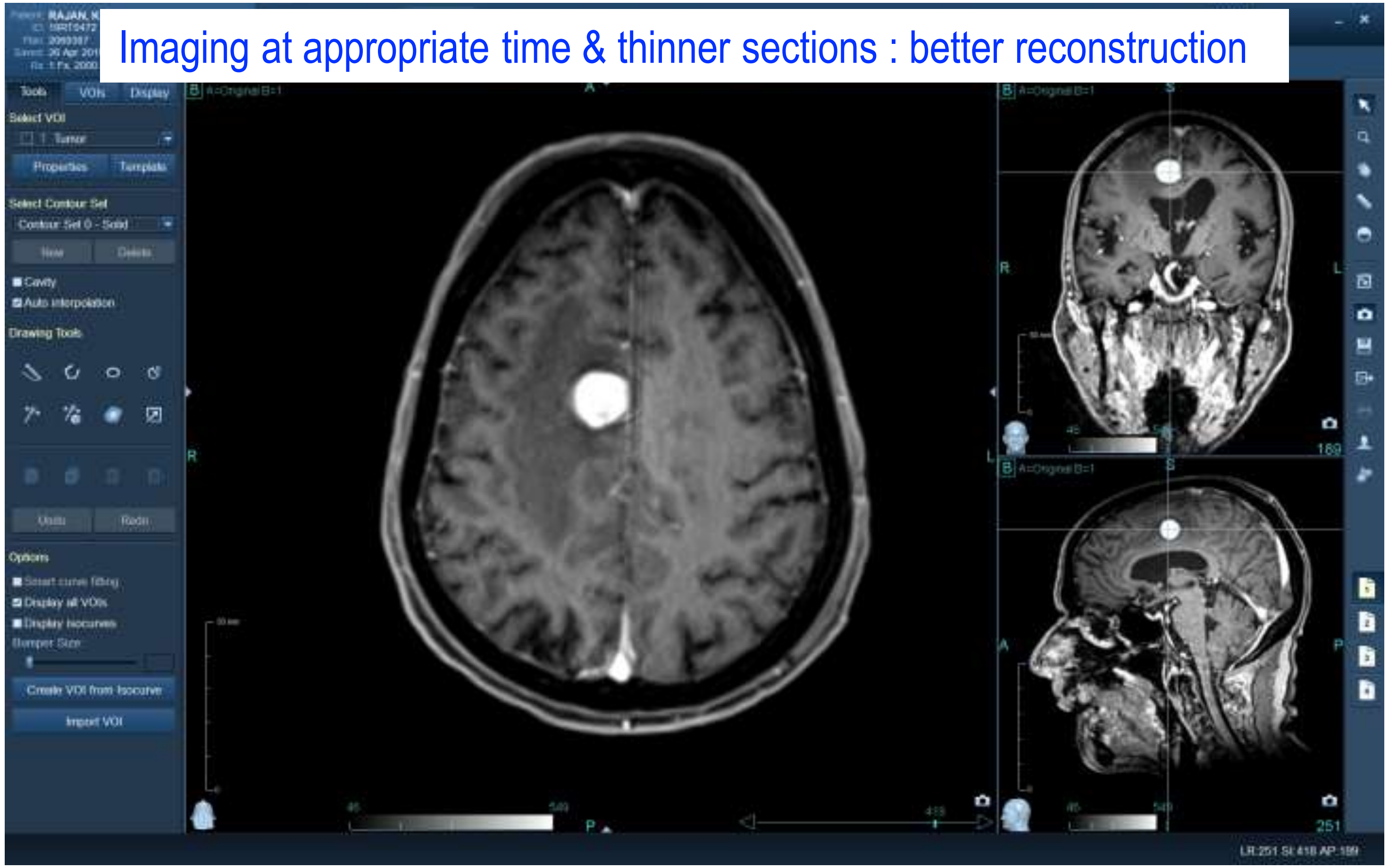
Brain : 0.65 mm

Lung: 1.25 mm

Pelvis / abdomen: 1.25 mm

Thick scan will give poor reconstructed images

Imaging at appropriate time & thinner sections : better reconstruction



CT scan: DOUBLE contrast

Contrast scan using double the amount of standard contrast

2mg/kg body wt

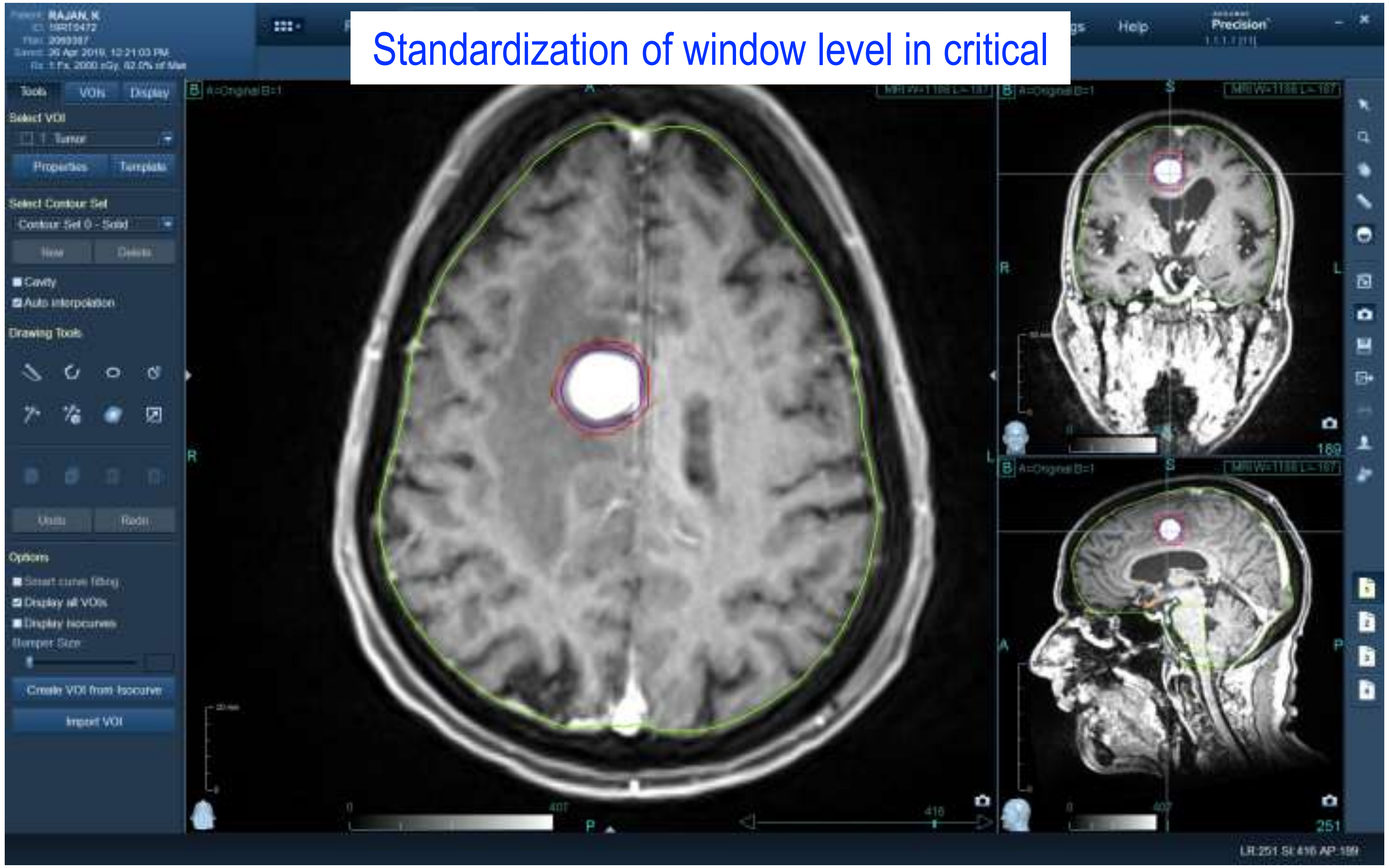
Brain – 60mg

Abdomen / Pelvis – 80 mg

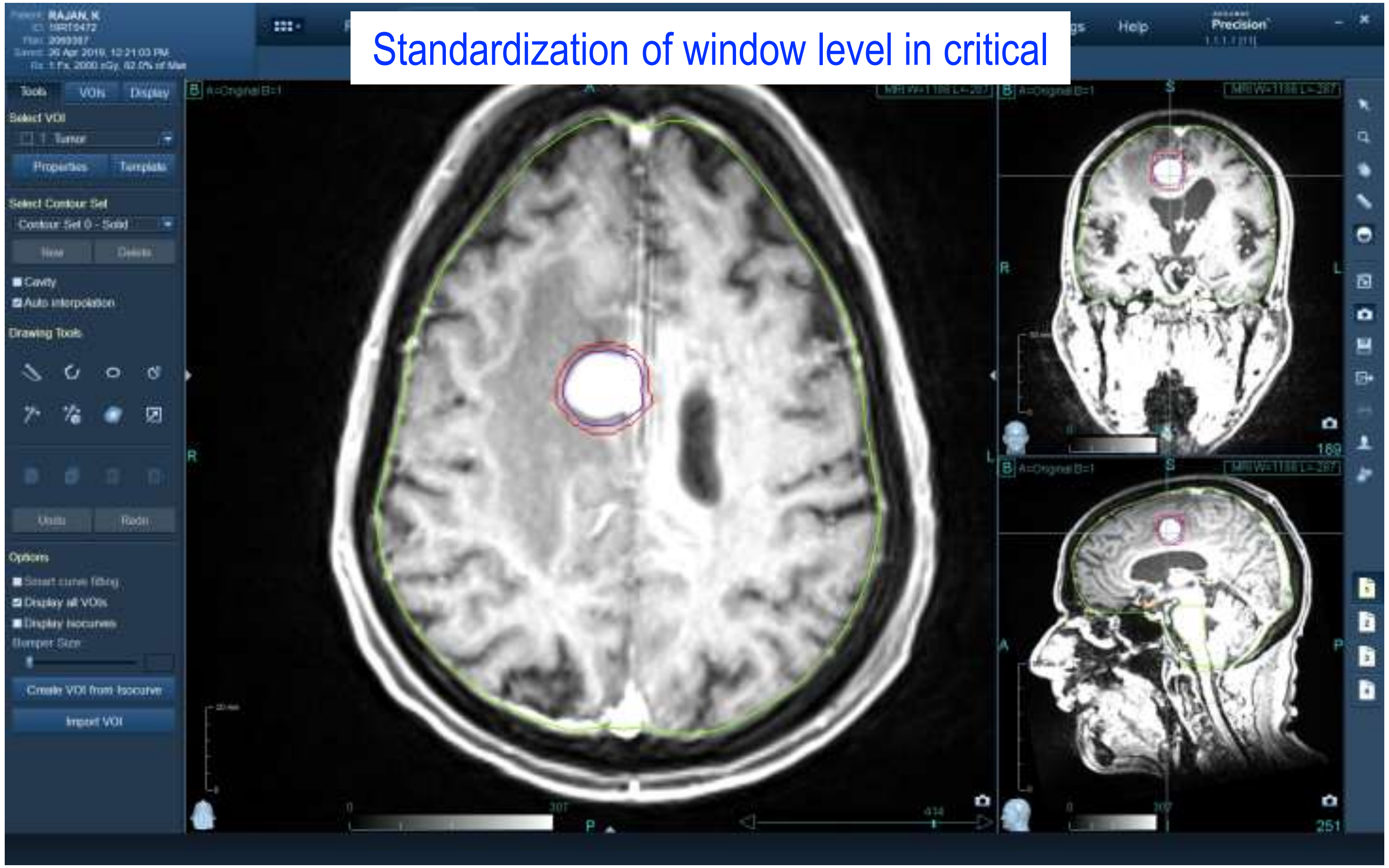
Better delineation of target

Standardization of window level in critical

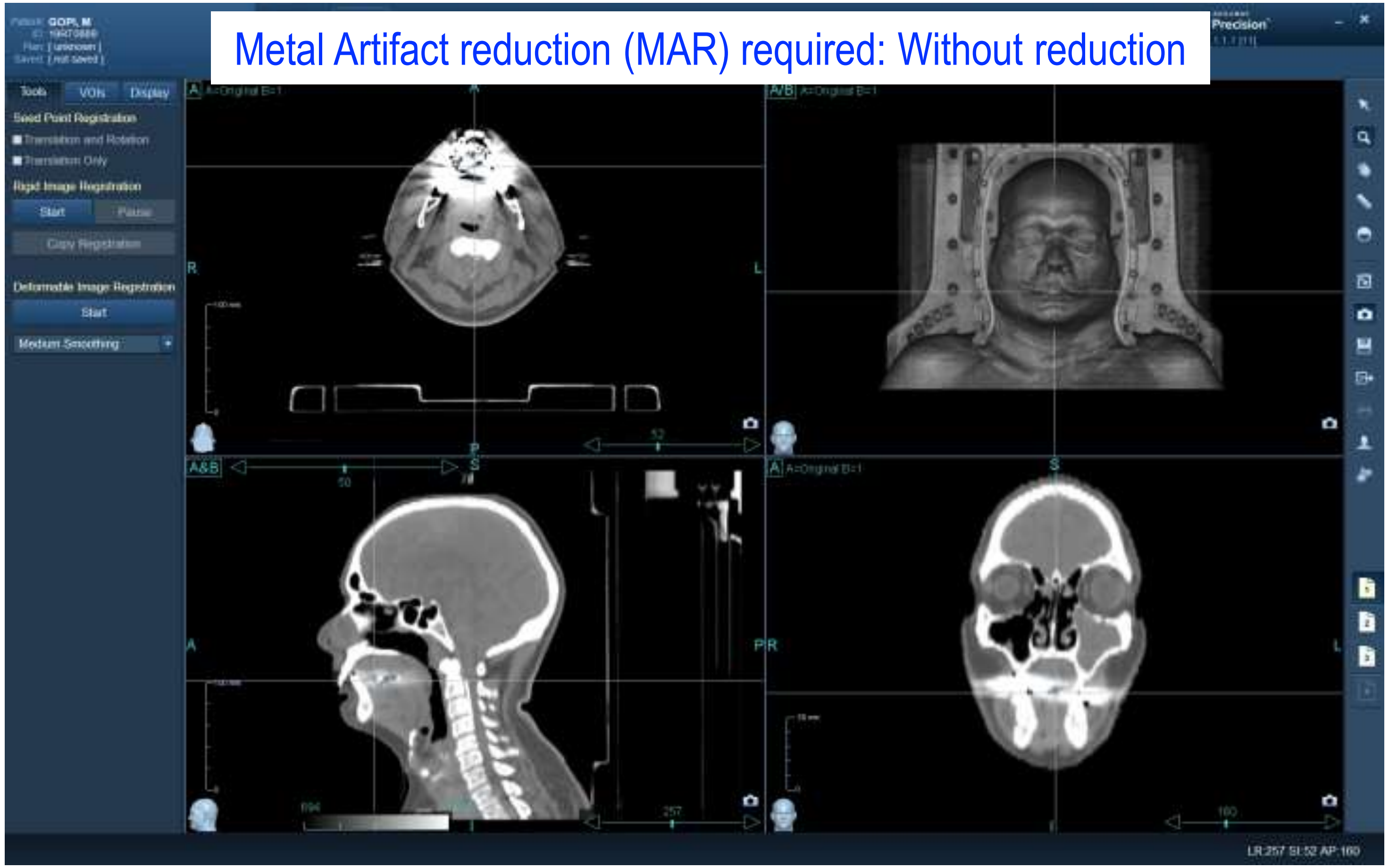
Standardization of window level in critical



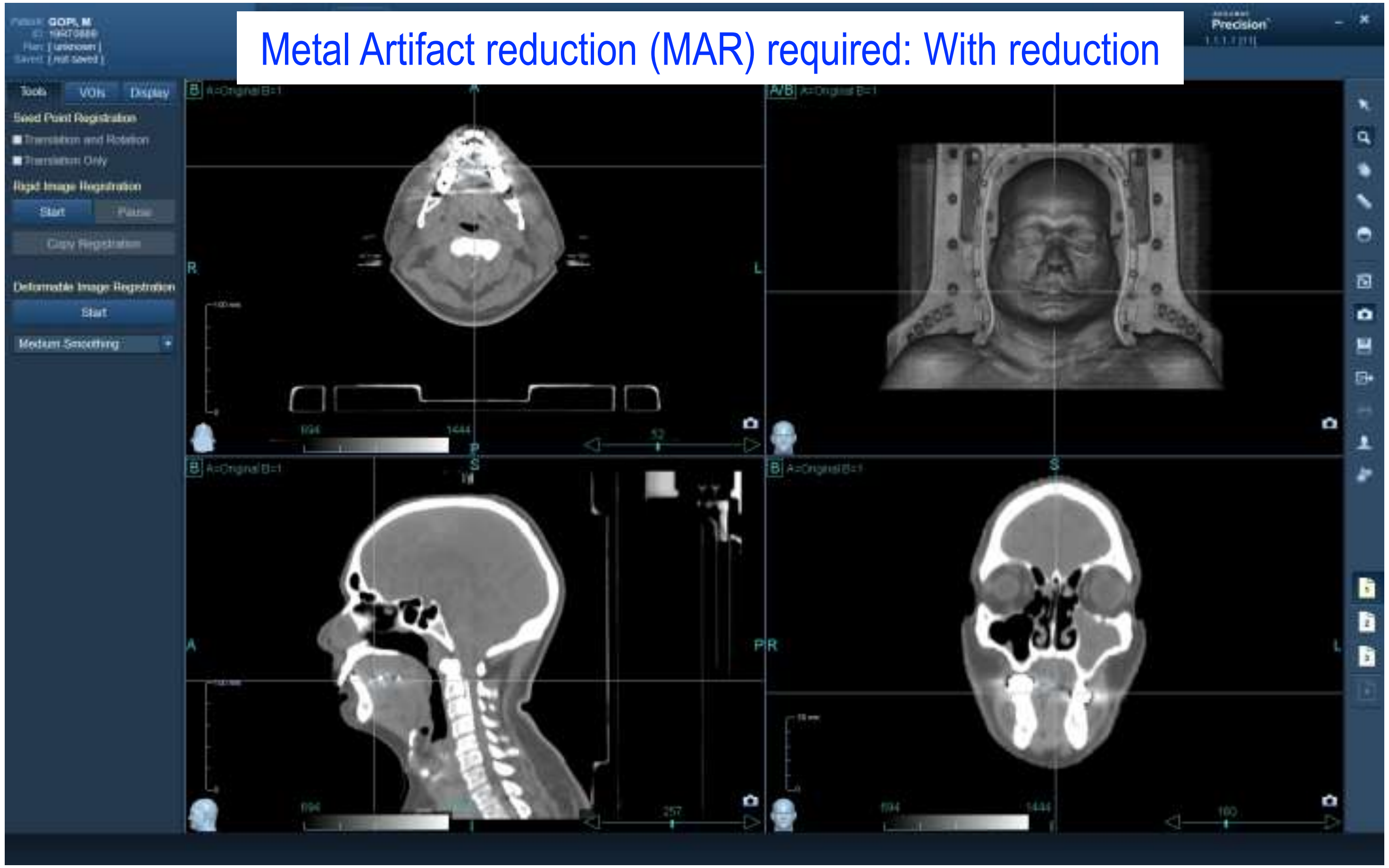
Standardization of window level in critical



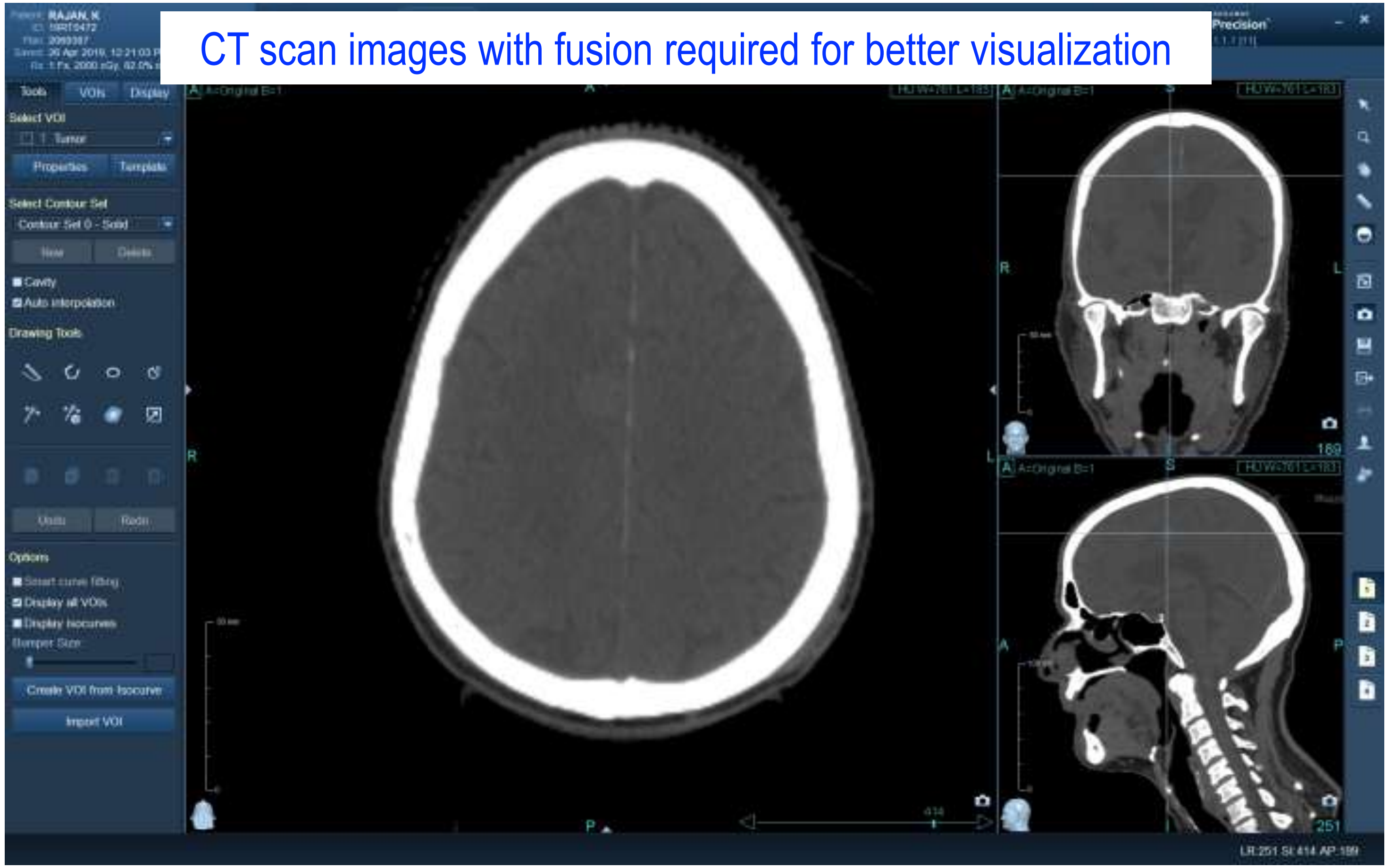
Metal Artifact reduction (MAR) required: Without reduction



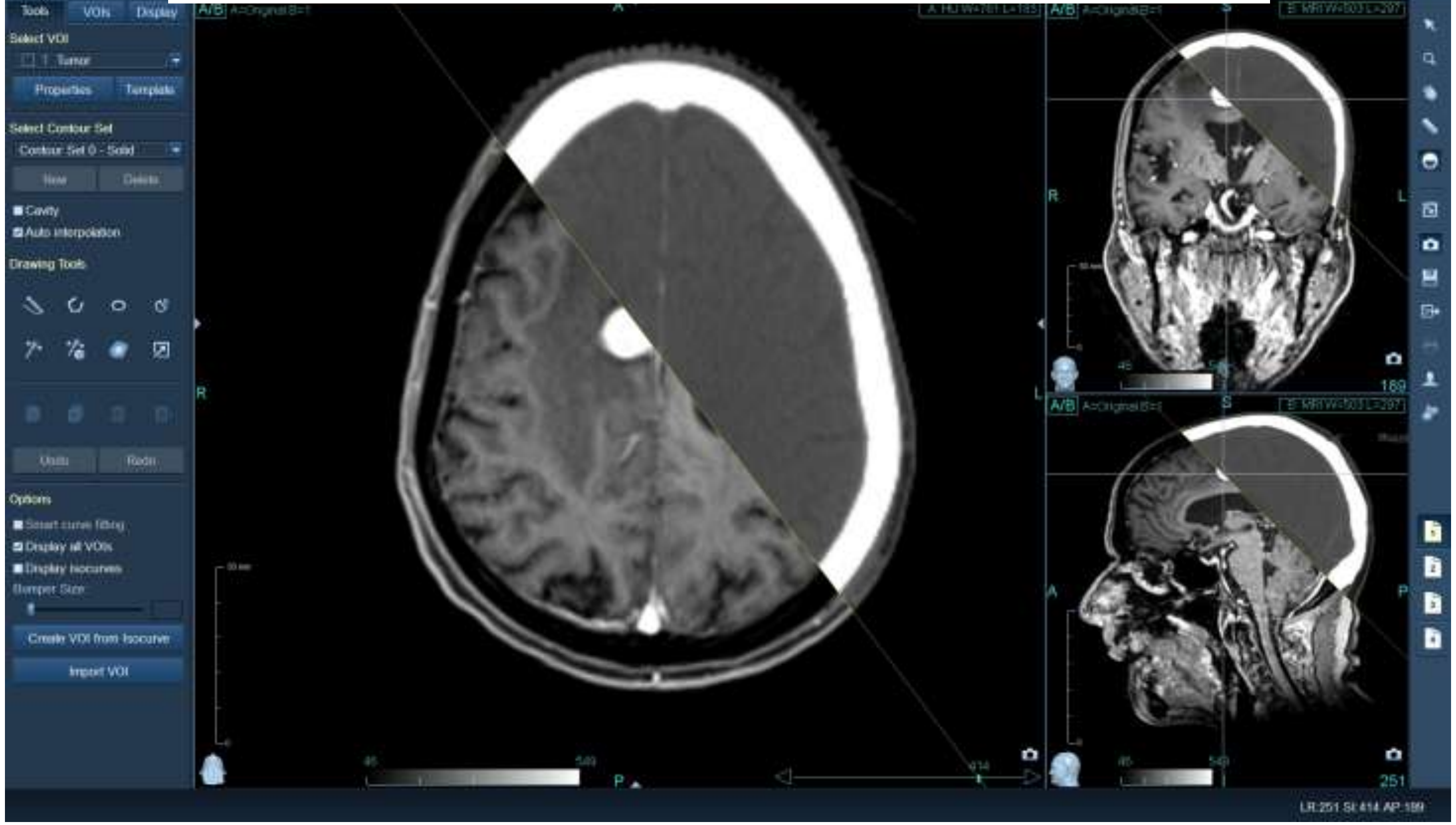
Metal Artifact reduction (MAR) required: With reduction



CT scan images with fusion required for better visualization



CT scan images with fusion required for better visualization



Radiosurgery: Tolerance SRS

Serial Tissue	Volume (mL)	Volume Max (Gy)	Max Point Dose (Gy)	Endpoint (≥Grade 3)
SINGLE-FRACTION TREATMENT				
Optic pathway	<0.2	8	10	Neuritis
Cochlea			12	Hearing loss
Brainstem	<1	10	15	Cranial neuropathy
Spinal cord	<0.25	10	14	Myelitis
	<1.2	7		

Serial Tissue	Volume (mL)	Volume Max (Gy)	Max Point Dose (Gy)	Endpoint (≥Grade 3)
THREE-FRACTION TREATMENT				
Optic pathway	<0.2	15 (5 Gy/fx)	19.5 (6.5 Gy/fx)	Neuritis
Cochlea			20 (6.67 Gy/fx)	Hearing loss
Brainstem	<1	18 (6 Gy/fx)	23 (7.67 Gy/fx)	Cranial neuropathy
Spinal cord	<0.25	18 (6 Gy/fx)	22 (7.33 Gy/fx)	Myelitis
	<1.2	11.1 (3.7 Gy/fx)		
Cauda equina	<5	21.9 (7.3 Gy/fx)	24 (8 Gy/fx)	Neuritis
Sacral plexus	<3	22.5 (7.5 Gy/fx)	24 (8 Gy/fx)	Neuropathy
Esophagus*	<5	21 (7 Gy/fx)	27 (9 Gy/fx)	Stenosis/fistula
Ipsilateral brachial plexus	<3	22.5 (7.5 Gy/fx)	24 (8 Gy/fx)	Neuropathy

Serial Tissue	Volume (mL)	Volume Max (Gy)	Max Point Dose (Gy)	Endpoint (≥Grade 3)
FIVE-FRACTION TREATMENT				
Optic pathway	<0.2	20 (4 Gy/fx)	25 (5 Gy/fx)	Neuritis
Cochlea			27.5 (5.5 Gy/fx)	Hearing loss
Brainstem	<1	26 (5.2 Gy/fx)	31 (6.2 Gy/fx)	Cranial neuropathy
Spinal cord	<0.25	22.5 (4.5 Gy/fx)	30 (6 Gy/fx)	Myelitis
	<1.2	13.5 (2.7 Gy/fx)		

Equivalent dose calculation with LQ model

Table 1. Dose per fraction for different numbers of fractions to achieve the same NTD of 60, 80, 100 and 120 Gy at 2-Gy fractions

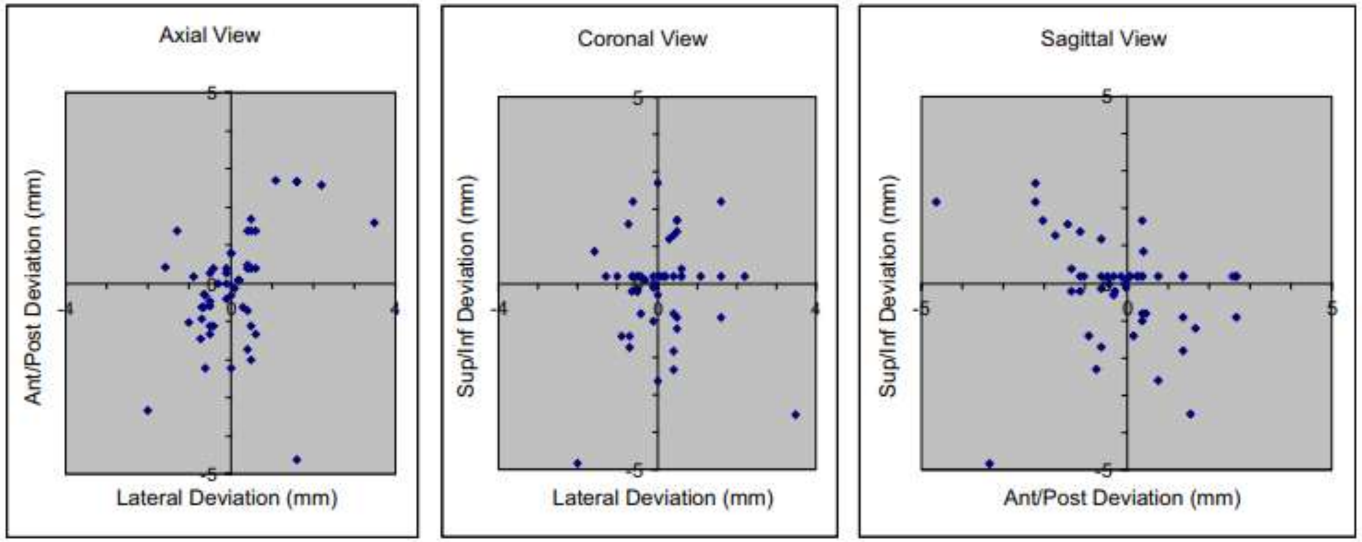
		Dose per fraction for hypofractionation with different number of fractions (Gy)							
NTD (Gy)	Conventional fractionation	1 F	2 F	3 F	4 F	5 F	6 F	10 F	20 F
60	2 Gy × 30 F	22.30	14.62	11.28	9.32	8	7.04	4.85	2.81
80	2 Gy × 40 F	26.39	17.47	13.57	11.28	9.73	8.60	6	3.54
100	2 Gy × 50 F	30	20	15.62	13.03	11.28	10	7.04	4.22
120	2 Gy × 60 F	33.28	22.29	17.47	14.62	12.69	11.28	8	4.85

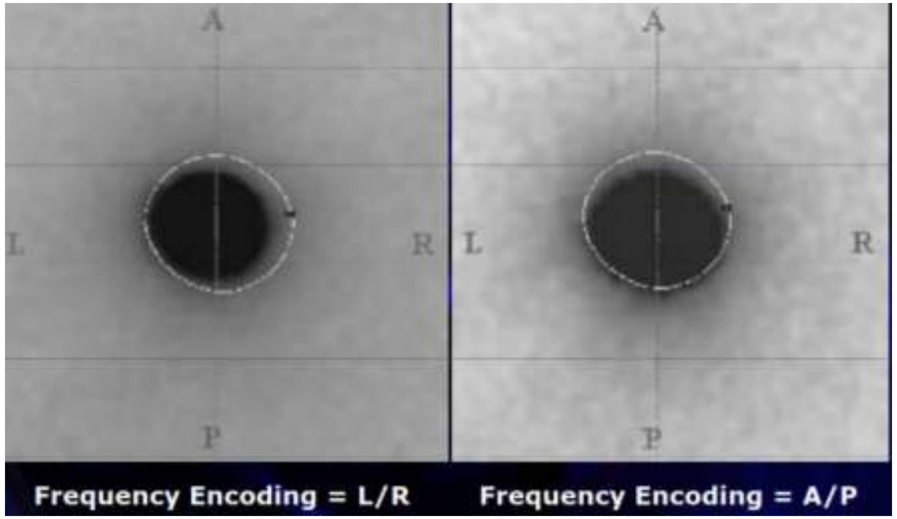
Abbreviations: NTD = normalized tumor dose; F = fraction(s).

Dose per fraction, alpha/beta ratio

- Equivalent tumour control probability
- Equivalent normal tissue toxicity probability
- Different ‘iso-effective’ dosage schedule

PTV margin





1.8 ± 0.5 mm shift of MR images relative to CT and delivered dose. Shifts occur in the frequency encoding direction

Set up error, mechanical error, image fusion error, MRI scan distortion error
PTV margin of 1-3 mm is required

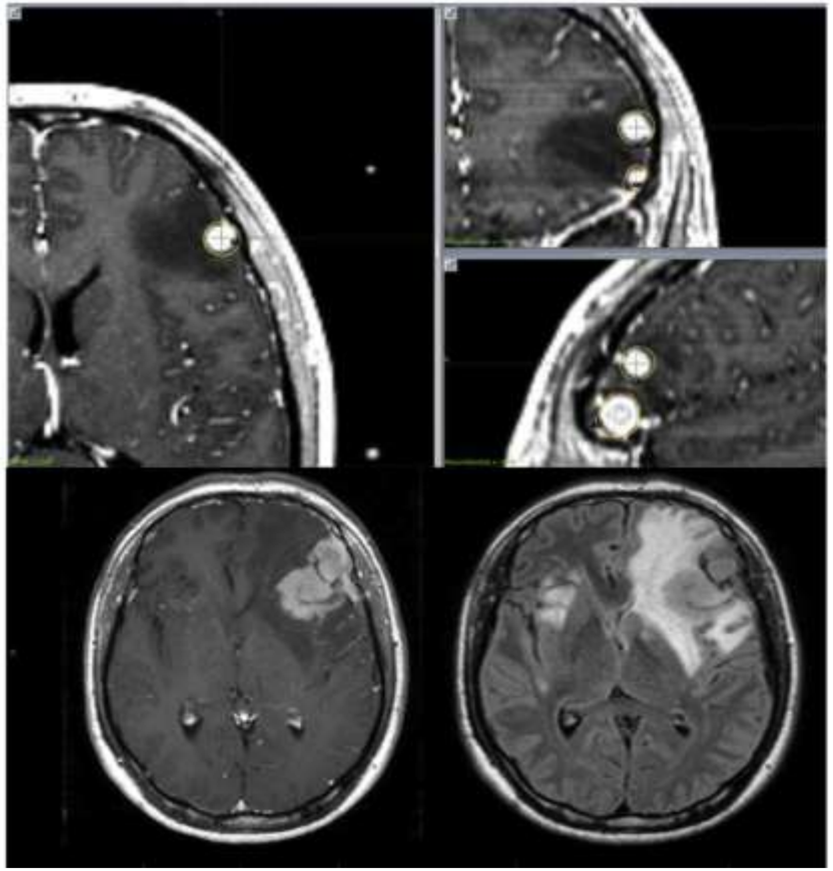
Image distortion in MRI-based polymer gel dosimetry of Gamma Knife stereotactic radiosurgery systems
Results of a multi-institutional benchmark test for cranial ct/mr image registration

Y Watanabe et al, Med Phy 2001

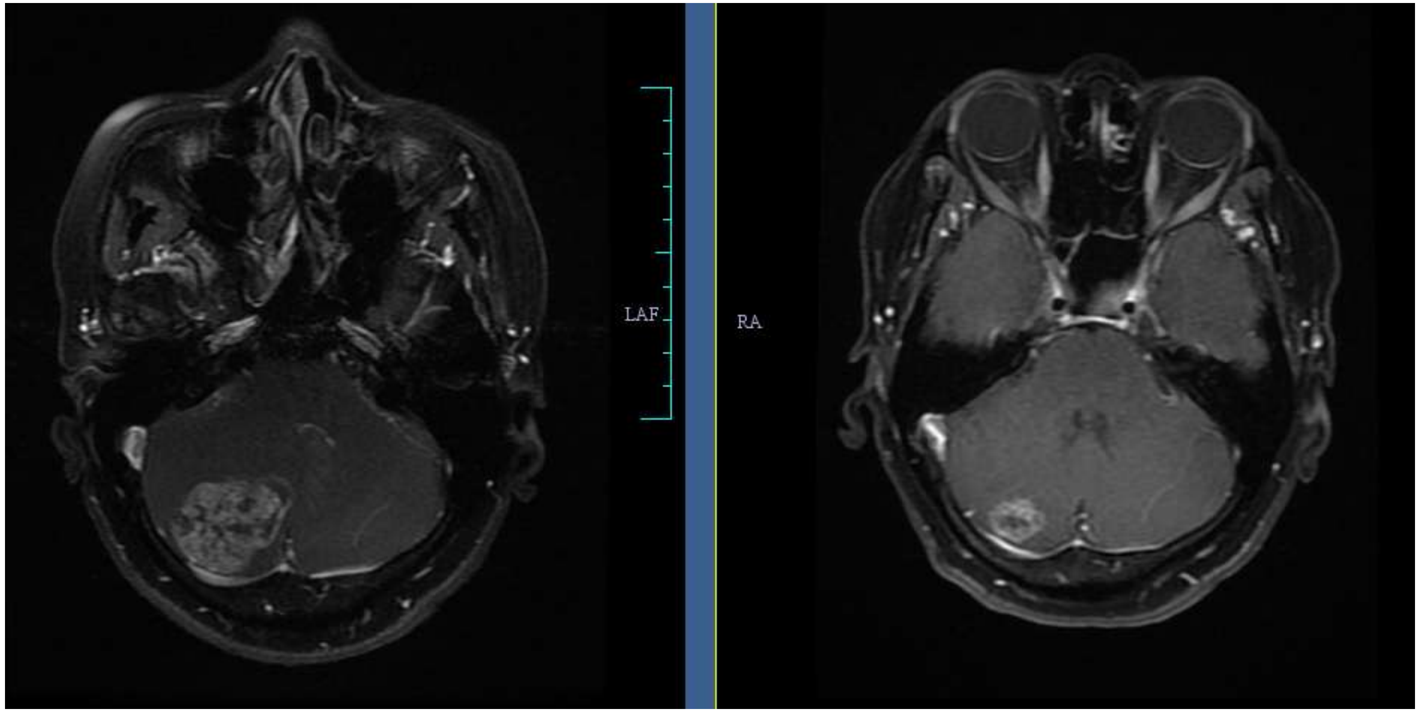
Ulin et al. IJROBP 2010

Response depends upon radio-sensitivity

20Gy/1fr

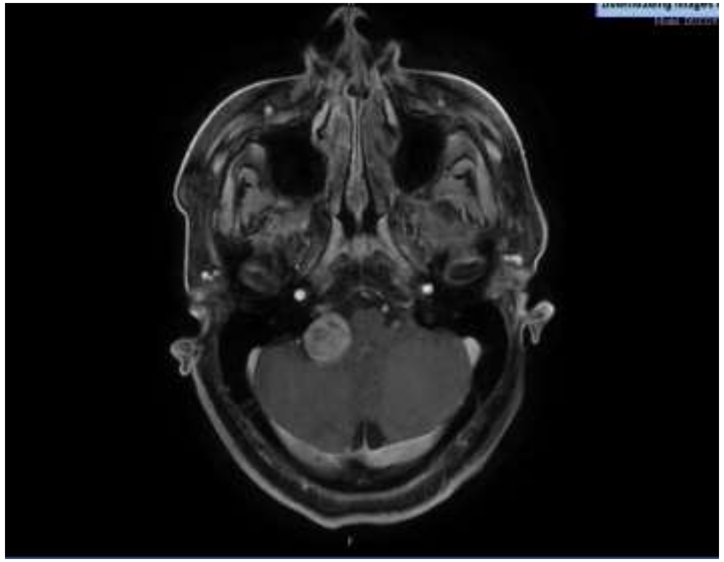


Renal cell Carcinoma primary

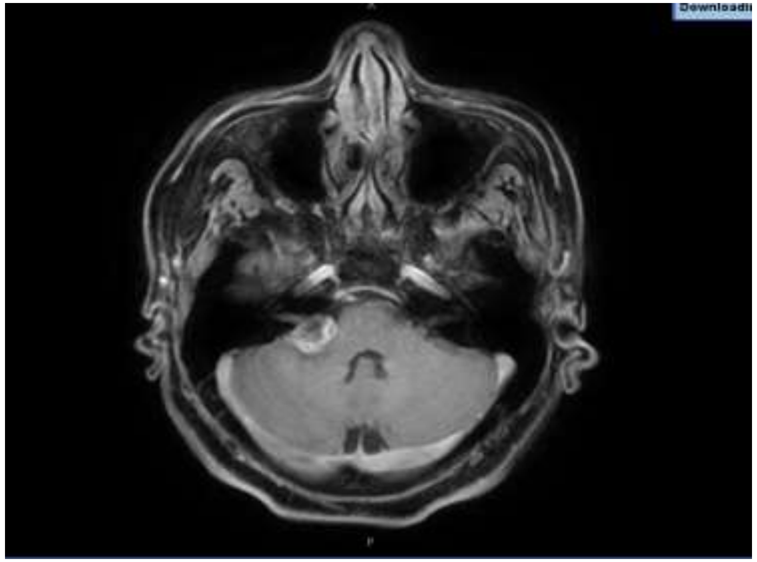


Breast Cancer primary

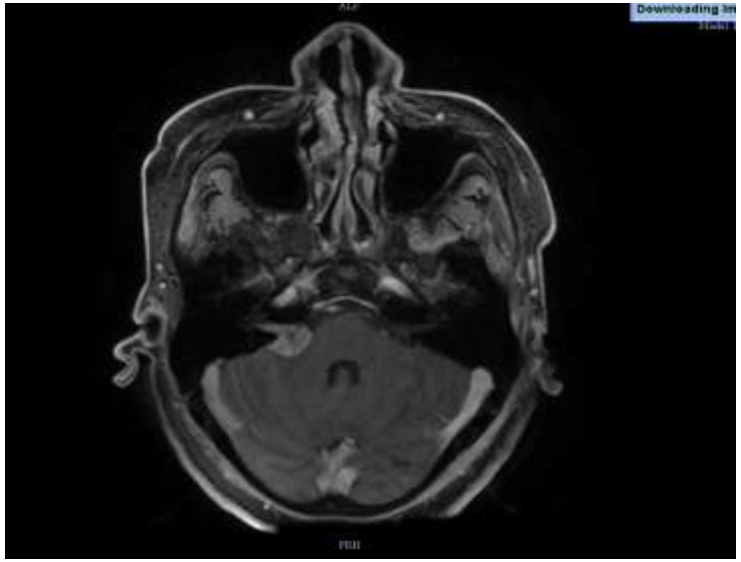
Response assessment



Baseline



2 years f/u



4 years f/u

Prospective evaluation of AN pts (n=162)

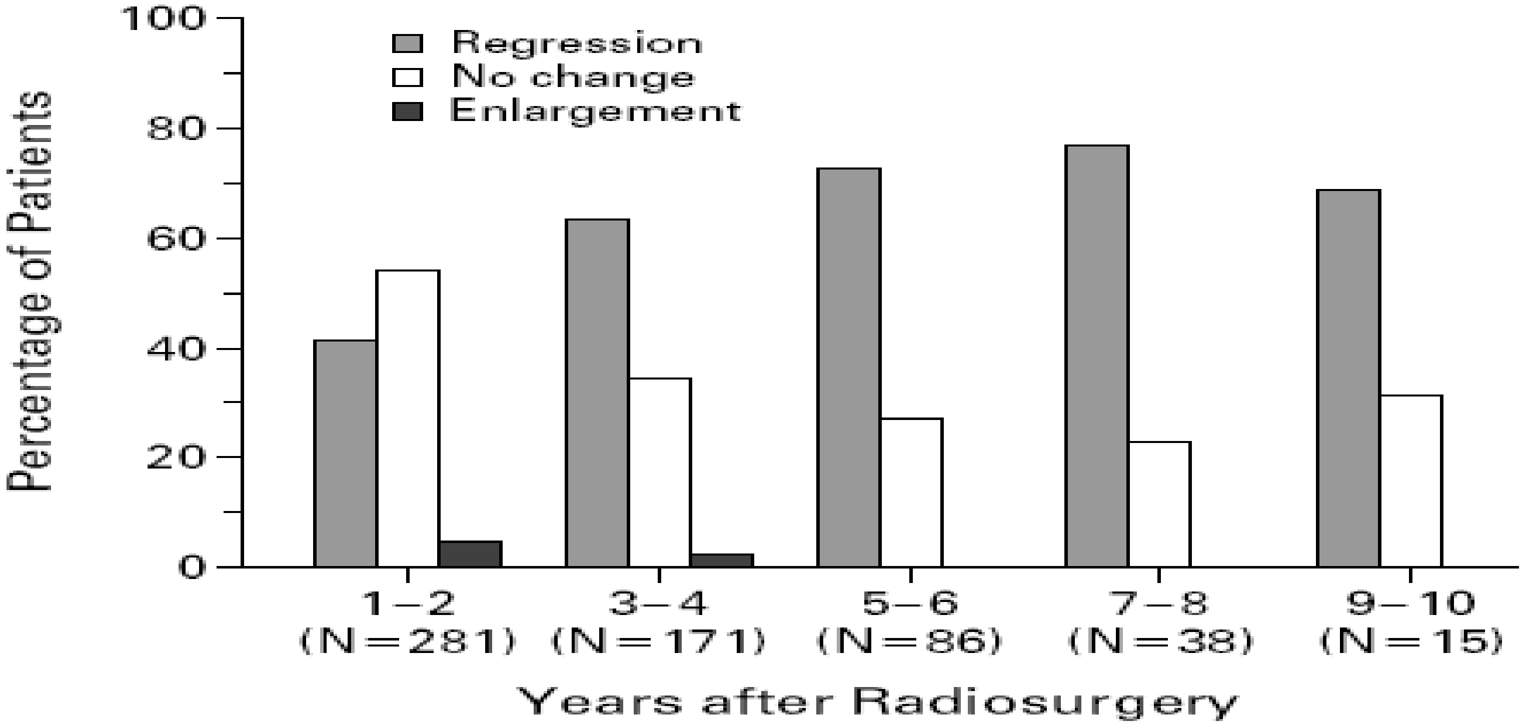


Figure 2. Percentages of Patients in Whom Tumors Regressed, Were Unchanged, or Became Larger during the 10 Years of Evaluation after Radiosurgery.

Regression of tumour in majority of pts
Regression is slow & occurs over years

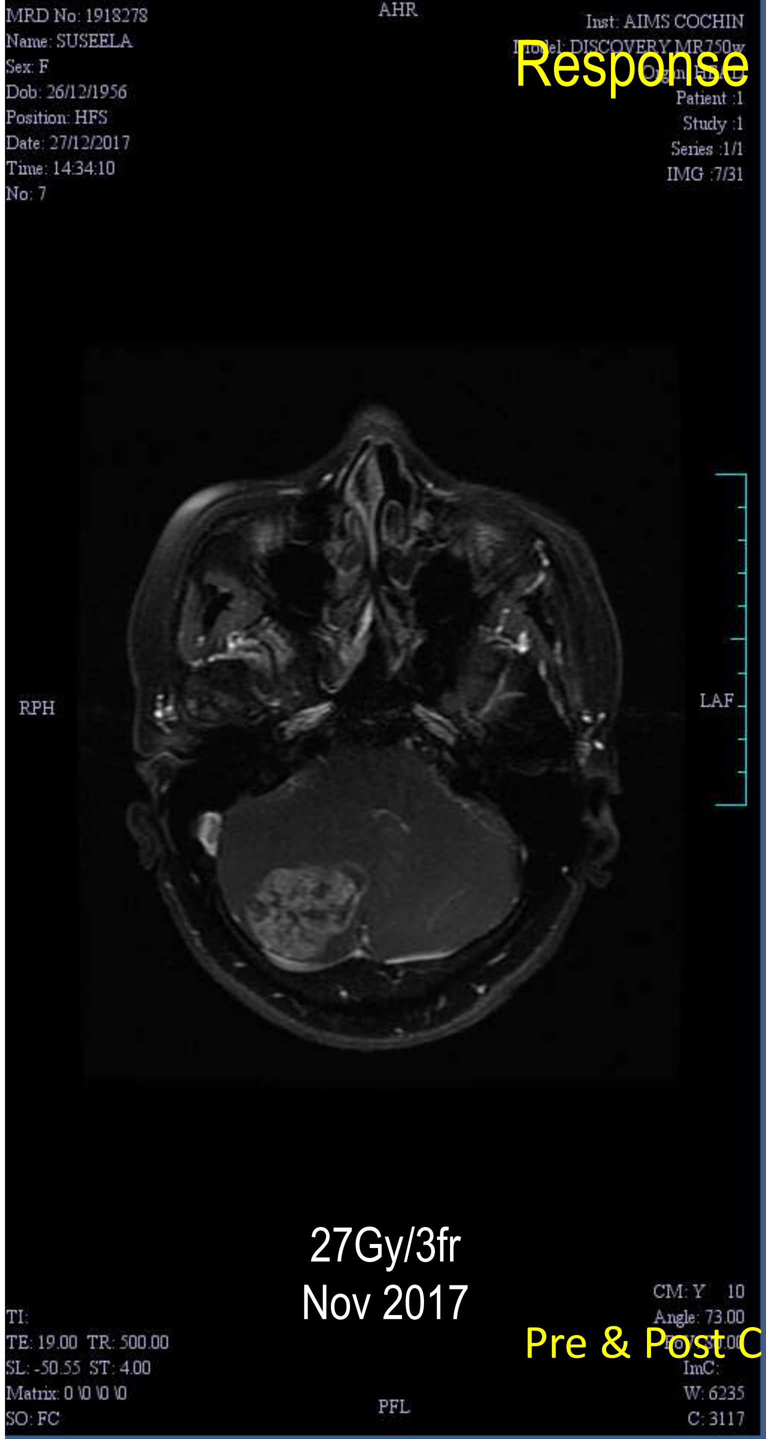
Kondziolka et al NEJM 1998

Response assessment

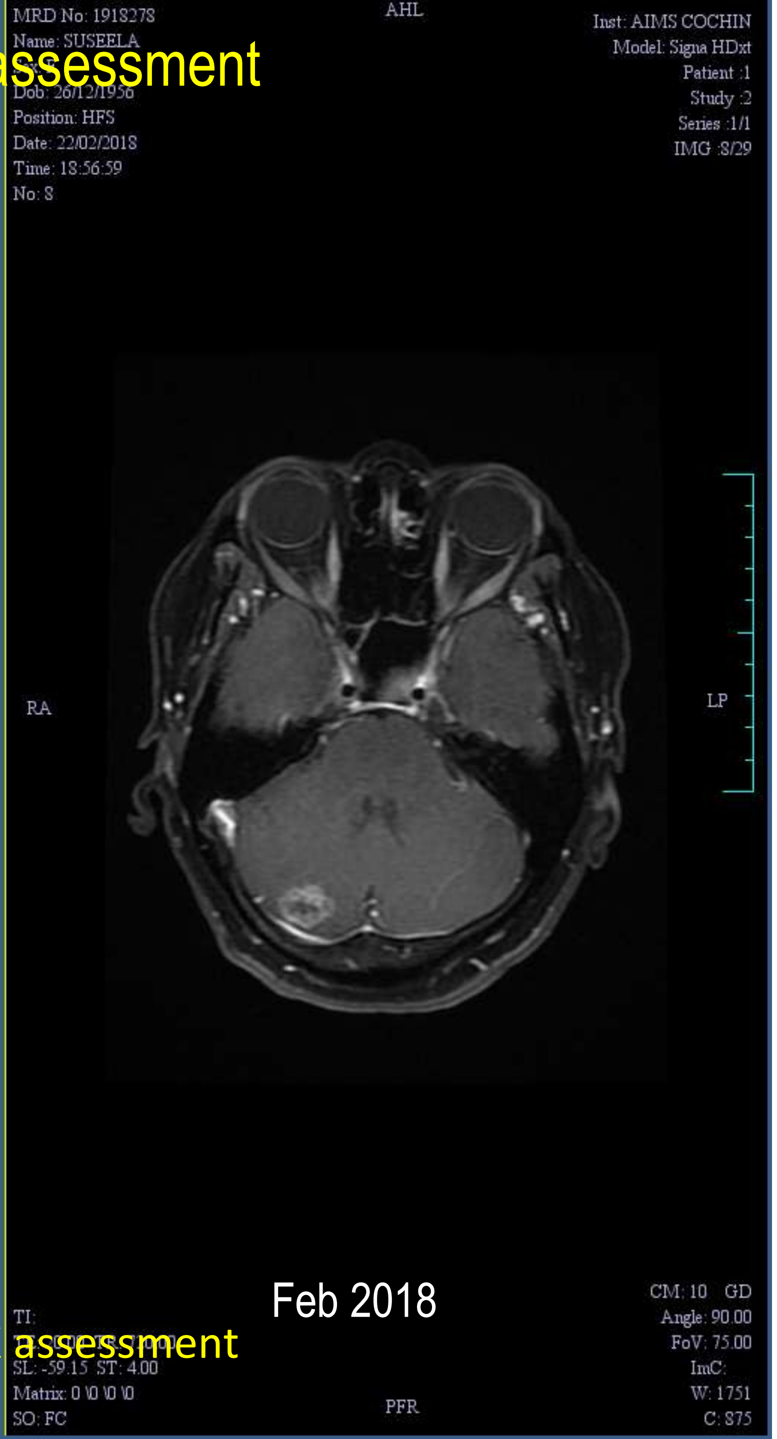
Pre-CK: 2020

Post-CK 3 years: 2023

Response assessment



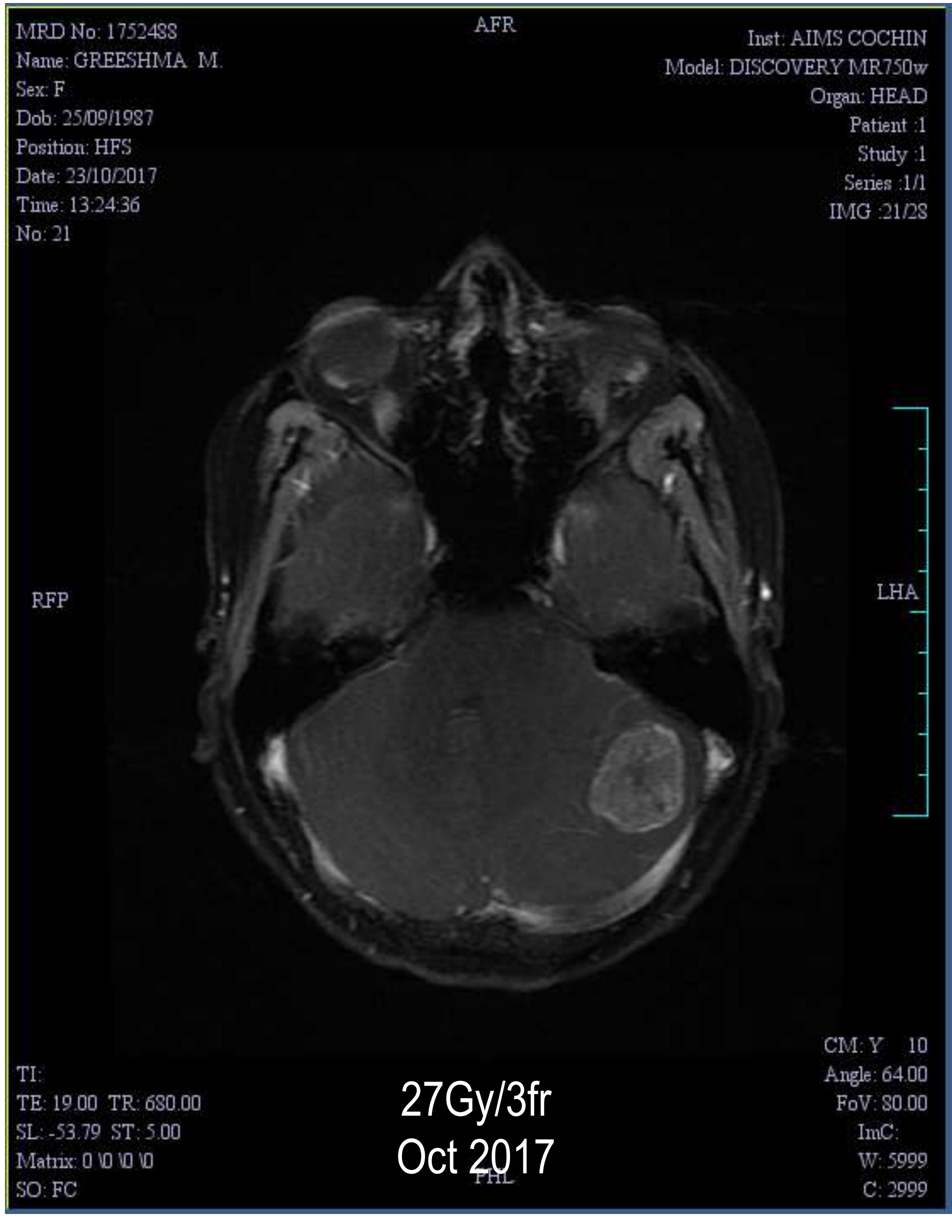
27Gy/3fr
Nov 2017



Feb 2018

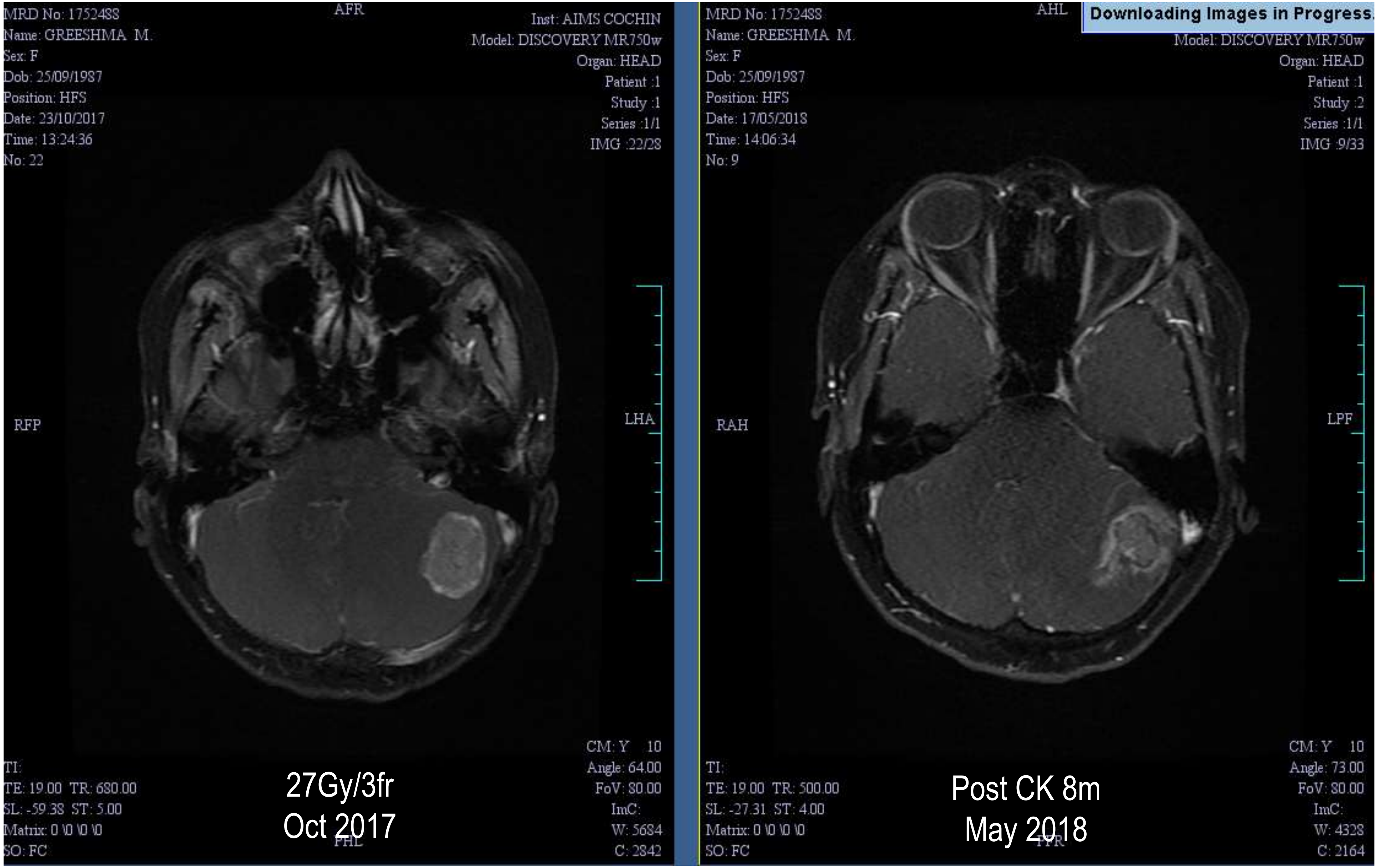
Pre & Post CK assessment

Necrosis



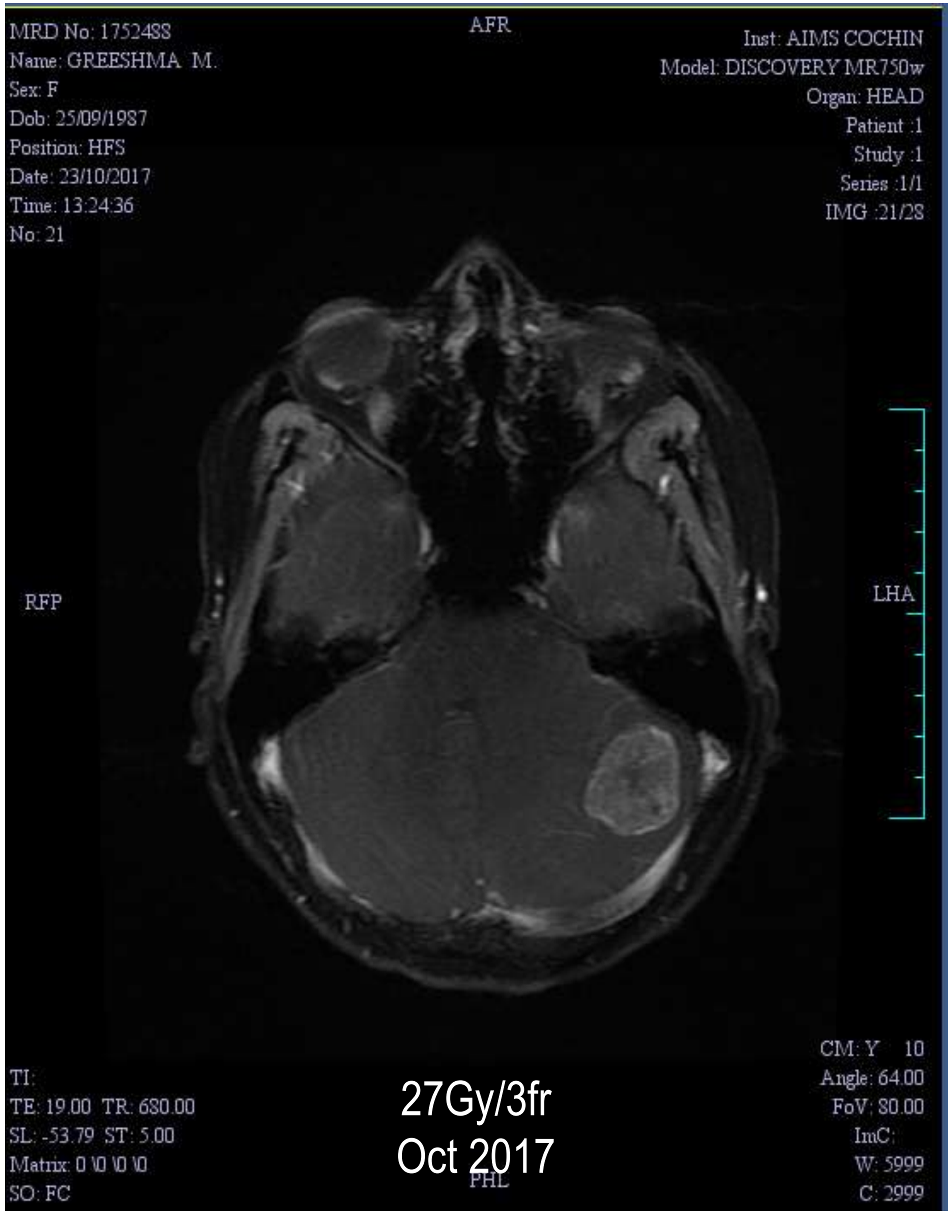
Contrast enhancement may not always be disease progression

Necrosis



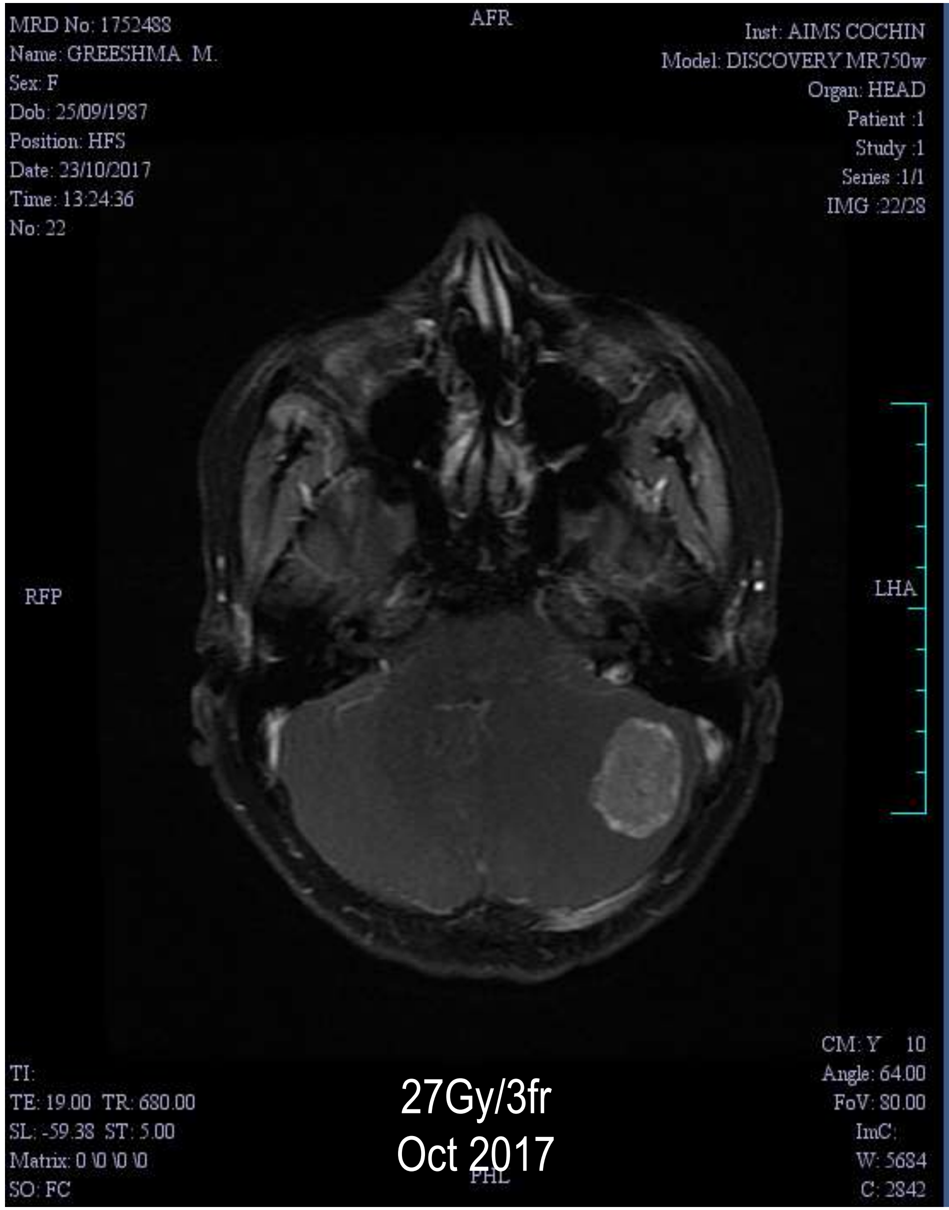
Contrast enhancement may not always be disease progression

Necrosis



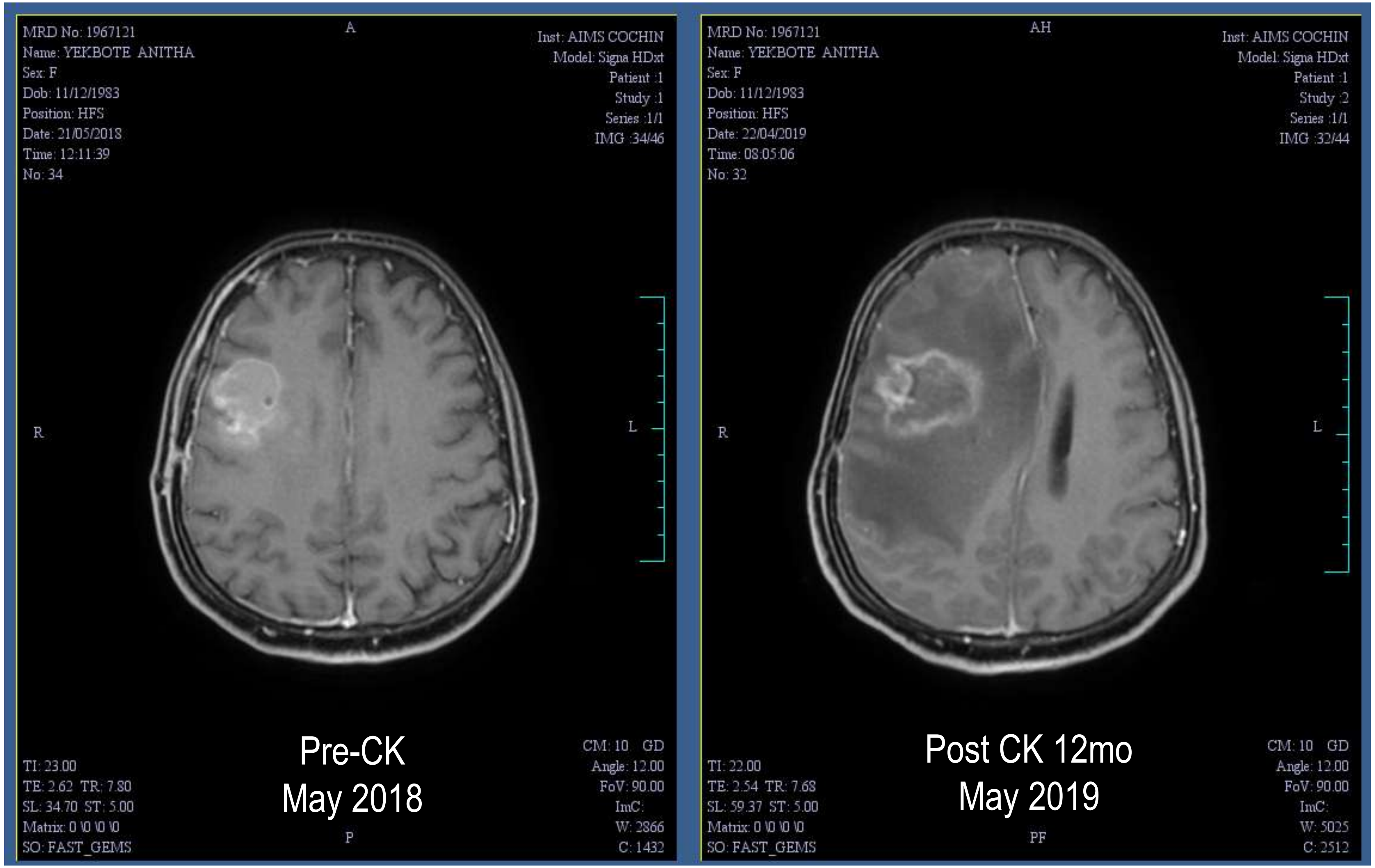
Contrast enhancement may not always be disease progression

Necrosis



27Gy/3fr
Oct 2017

Post CK 12m
Oct 2018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A
Inst: AIMS COCHIN
Model: Signa HDxt
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Study :1
Series :1/1
IMG :34/46
R
L
TI: 23.00
TE: 2.62 TR: 7.80
SL: 34.70 ST: 5.00
Matrix: 0 \0 \0 \0
SO: FAST_GEMS
Pre-CK
May 2018
P
CM: 10 GD
Angle: 12.00
FoV: 90.00
ImC:
W: 2866
C: 1432
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Dob: 11/12/1983
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L
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Post CK 12mo
May 2019
PF
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ImC:
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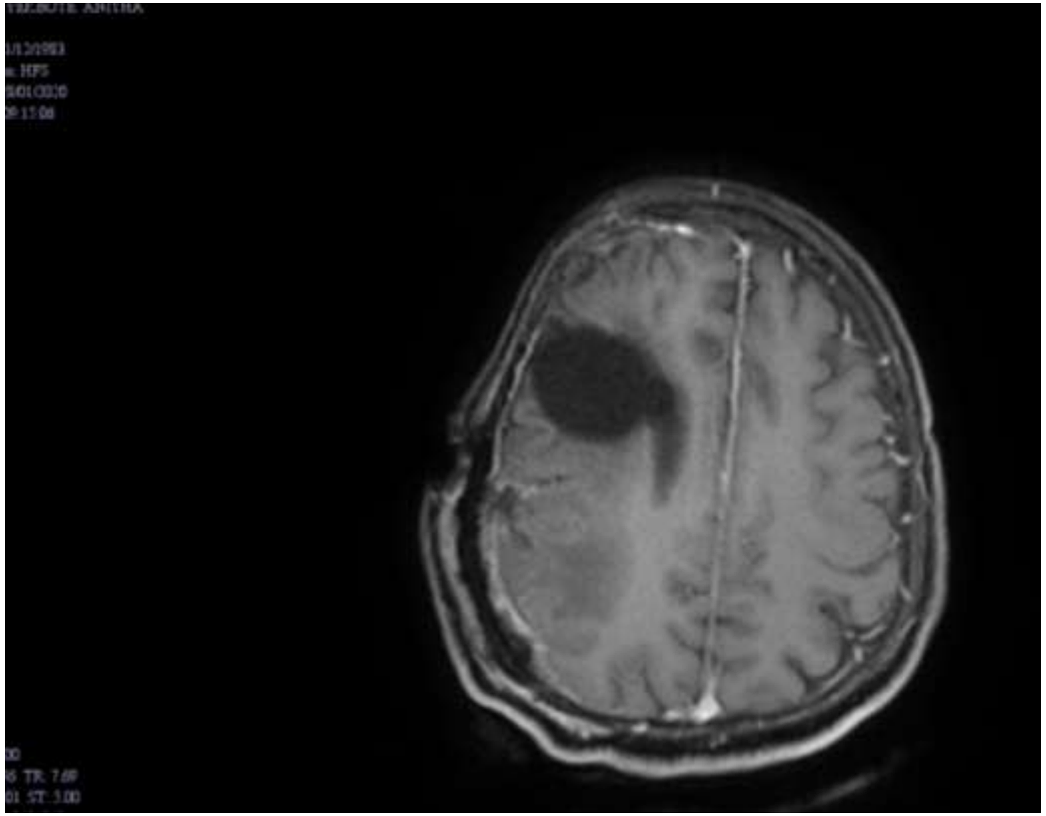
C: 2512

CK 24Gy/1fr



Post-OP
Sep 2019

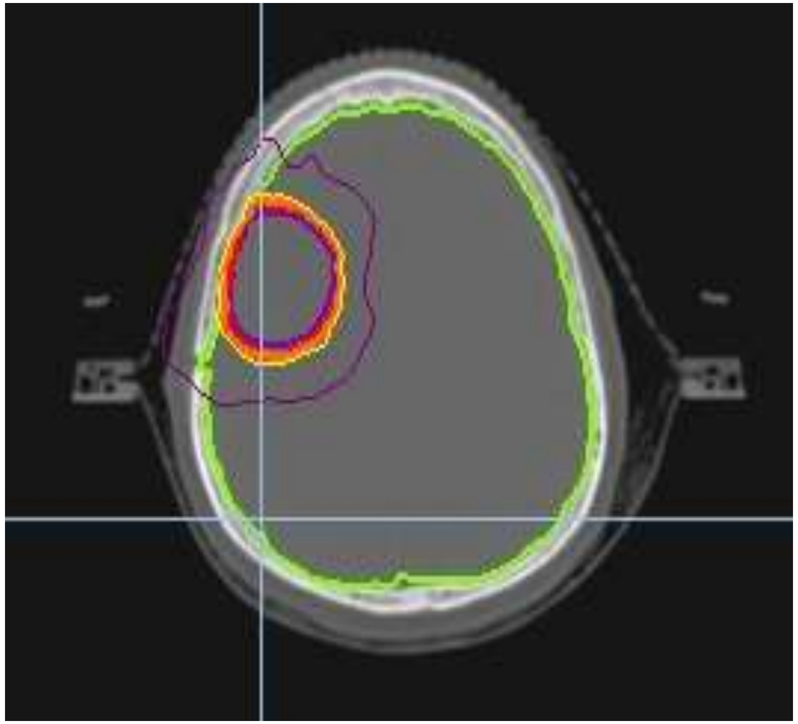
Post-OP
Jan 2020

Surgery done
Only radiation necrosis
NO viable tissue

Brain metastasis – Toxicity depends upon

14Gy & 18Gy Normal brain dose predicts RN

18Gy normal brain vol in 3 fr SRS schedule	
Normal brain vol	RN (%)
<30cc	5%
>30cc	14%
<22.8cc	0%
22.8-30.2cc	6%
30.3-41.2cc	13%
>41.2cc	24%
14Gy normal brain vol in single fr SRS schedule	
>7cc	>14%
<7cc	<5%



Radionecrosis: 10-15%
In <3cm lesion, BED 90-127 (dose 24-35Gy/3-5fr): RN 2-15%

Inoue et al, Radiat Oncol 2014

Brain metastasis SRS: Dose Vs Response & Toxicity

Author	n	Vol	Dose	MS (mo)	1-yr Sur (%)	RN (%)
Fokas et al	102	Gr1: 2cc Gr2: 5.9cc	Gr1: 7x5Gy Gr2: 10x4Gy	Gr1: 7 mo Gr2: 10 mo	Gr1: 75% Gr2: 71%	Gr1: 1pt
Minniti et al	138	12.5cc	9Gyx3fr	13.4 mo	<3cm: 90% >3cm: 78%	<3cm: 9% >3cm: 14%
Navarria et al	102	Gr1: 2.1-3cm Gr2: 3.1-5cm	Gr1: 9Gyx3Fr Gr2: 8Gyx4fr	Gr1: 14mo Gr2: 14 mo	Gr1: 100% Gr2: 91%	5.8%
Murai et al	54	>2.5cm			Gr1: 66% Gr2: 65%	NIL
Fahrig et al	150	6cc	Gr1: 5x7Gy Gr2: 10x4Gy Gr3: 7x5Gy	Gr1: 11mo Gr2: 17mo	Gr1: 87% Gr2: 95% Gr3: 96%	1.3%
Rajakesari et al	70	1.7cm	5Gyx5fr	10.7 mo	56%	4.3%
Aoyama et al	87		9Gyx4fr	8.7 mo	81%	
Ernst Stecken et al	51	2.27	5x7Gy	11 mo	76%	2%

‘Hotter’ dose prescription: Better LC (1-Yr Sur), but higher RN
27Gy/3fr: LC 90% & RN 9%
25Gy/5fr: LC 56% & RN 4%

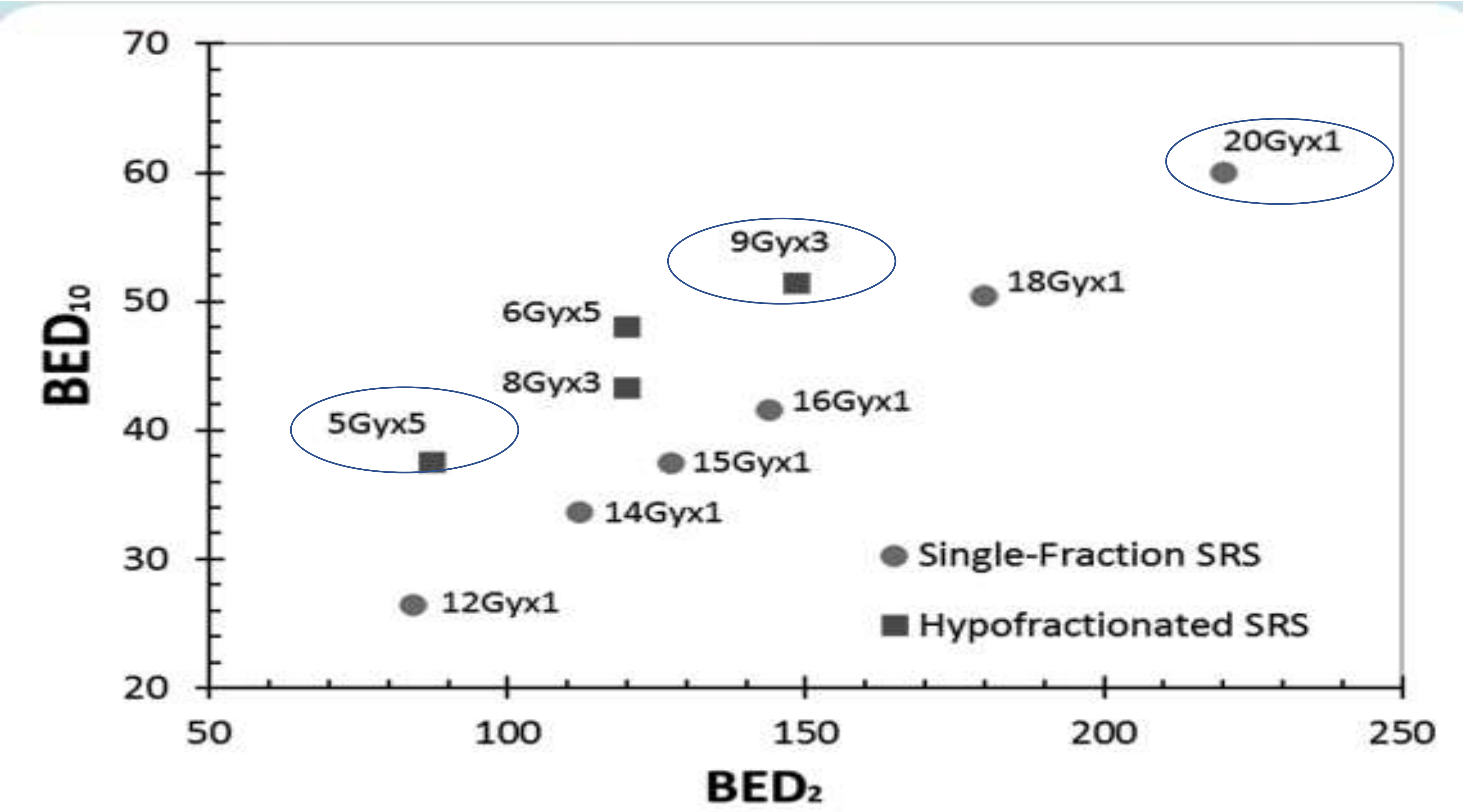
Brain metastasis SRS: Dose Vs Response

*Estimated percentage of patients in whom time to local failure exceeded 3, 6, 9, and 12 months**

Factor	Dose & Local Control Rate (95% CI)†		
	15 Gy	18 Gy	24 Gy
total no. of lesions	41	85	249
follow-up interval			
3 mos	100%	99% (96–100%)	100%
no. of lesions at risk	31	56	166
6 mos	71% (54–88%)	87% (77–96%)	92% (87–97%)
no. of lesions at risk	18	37	92
9 mos	63% (44–81%)	64% (49–80%)	85% (78–92%)
no. of lesions at risk	13	18	60
12 mos	45% (23–67%)	49% (30–68%)	85% (78–92%)
no. of lesions at risk	6	8	37

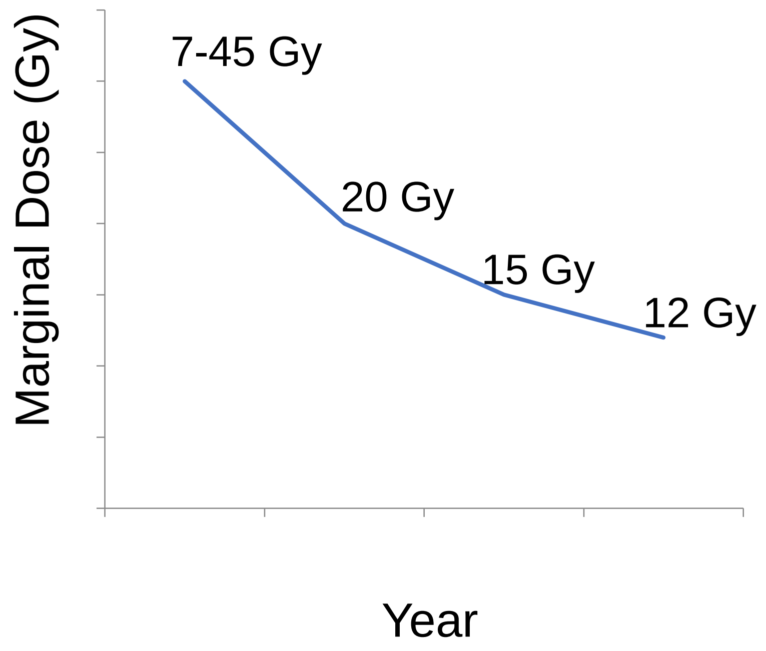
Vogelbaum MA et al, Neurosurg 2006

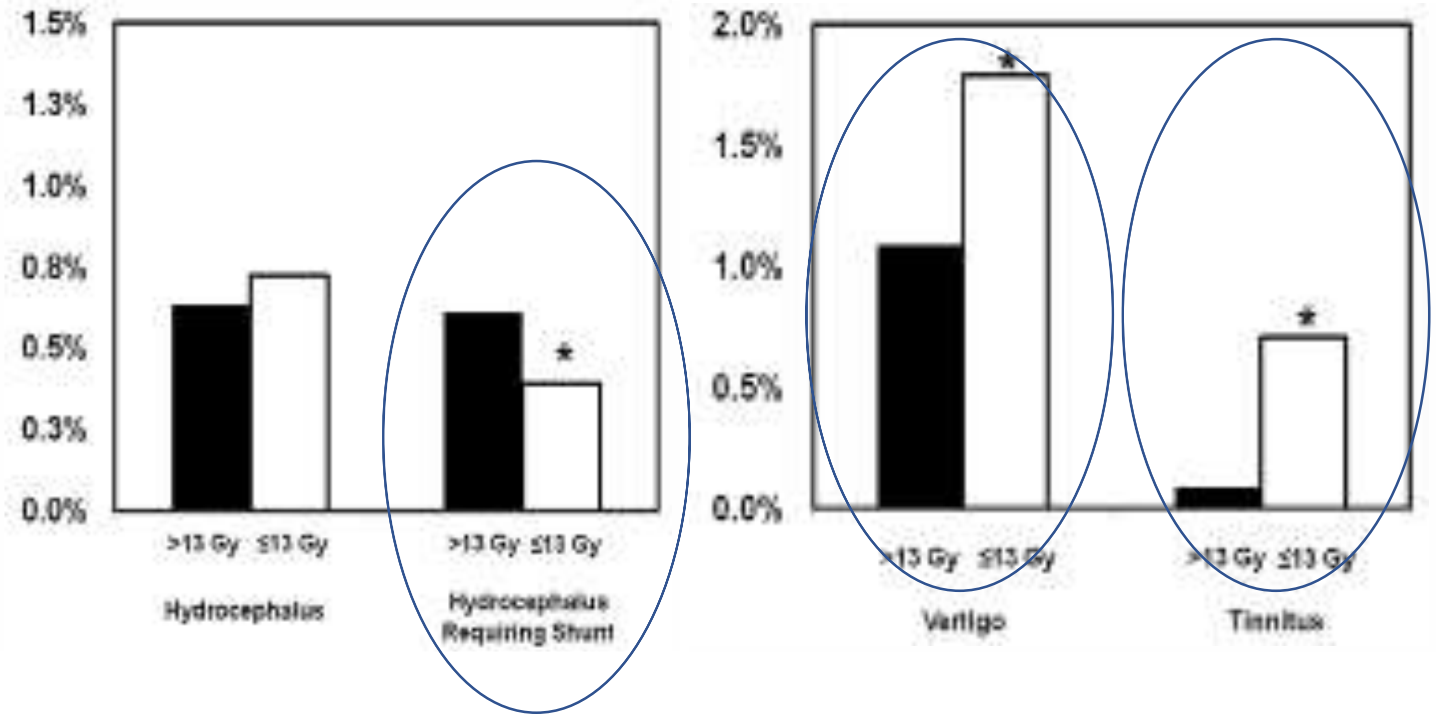
BED2 & BED10 for SRS & fSRS



Kirkpatrik JP, Neurooncology 2017

Acoustic schwannoma: Lower dose have better toxicity profile





Local control maintained (>95% at 10 years)
Toxicities have come down
Hearing preservation increased

Mendenhal et al 2000

Kondziolka et al NEJM 1998

Need for own outcome data

what Radiosurgery offers

In Benign conditions,

1. shorter course of treatment, 2) quality of life preservation, 3) preservation of functions

In Brain metastasis,

1. Preservation of cognitive function, 2. Response to treatment, 3. availability of treatment in new lesions

In Functional disorder,

1. Quality of life preservation, 2. Decrease in medication dependence, 3. reduction in pain

Availability of resources, expertise depends upon geographic location and socio-economic strata

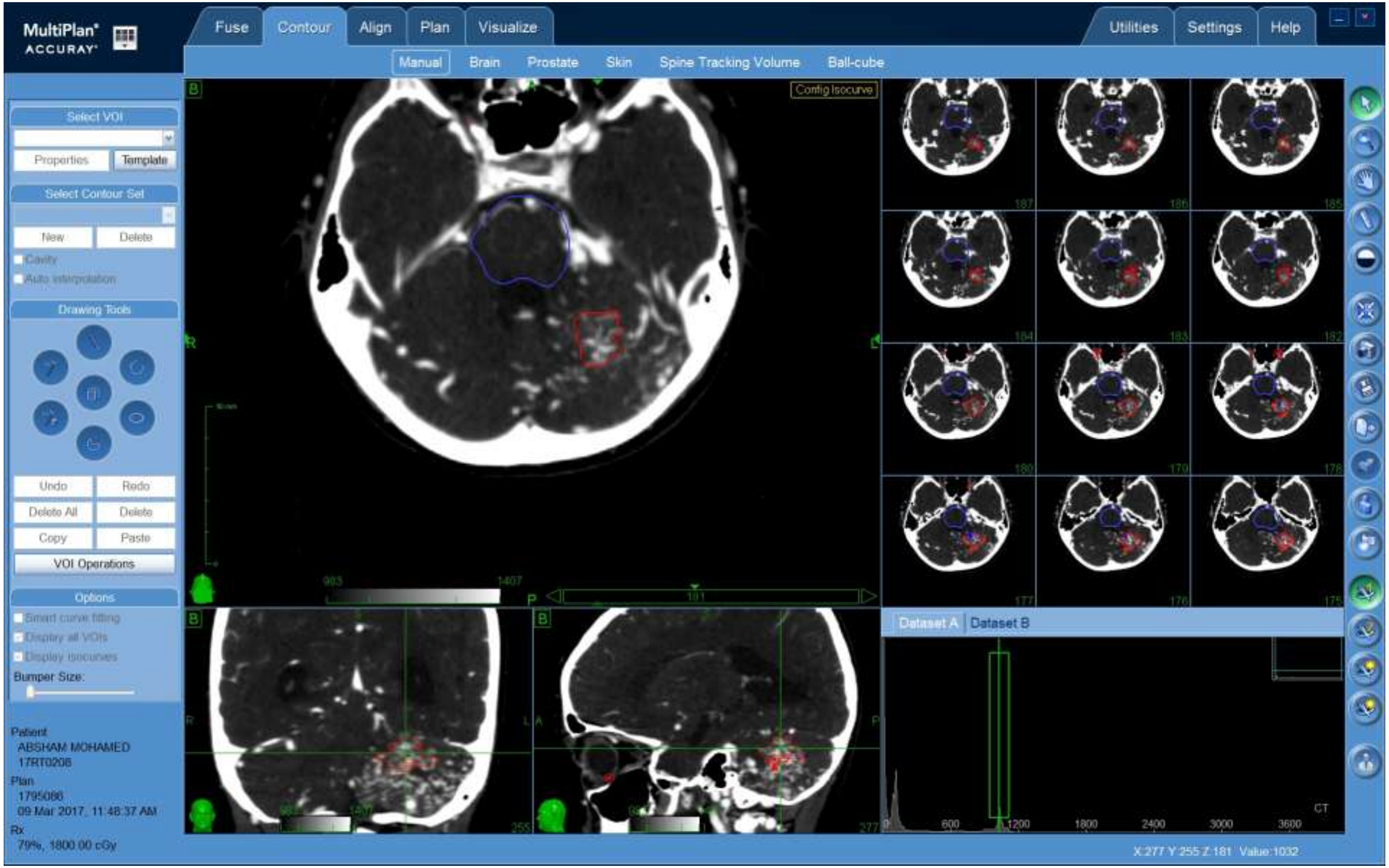
Hence, the expectation of outcome also depends upon different geographical population
Hence need own outcome data with radiosurgery

Micromultileaf collimator-based stereotactic radiosurgery for selected arteriovenous malformations: Technique and preliminary experience

Follow up (mo)	Mean	24.3 (1.57 to 71.2)
	Median	22
	Number of patient referred for SRS	87
	Number of patients planned for SRS	23
	Number of patients treated with SRS	21
LFU status clinical examination	No deficits	22
Neurological deficit persists after 2 yr FU		01
Type of Imaging done for Assessment		
	MRI and MRA done at 2 yrs FU	15
	DSA	12
	Imaging awaited on follow up	06
Last Follow up status on Imaging		
	MRA proven obliteration	15
	Obliteration confirmed on DSA	11
	No Obliteration on DSA	01
Complication after SRS		
	No complication	18
	Temporary worsening	02
	Persistent neurological deficit	01

Obliteration rate at 2 yr follow up DSA: 92%

Jalali R, Dutta D JCRT, 2008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Undo
Redo
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ABSHAM MOHAMED
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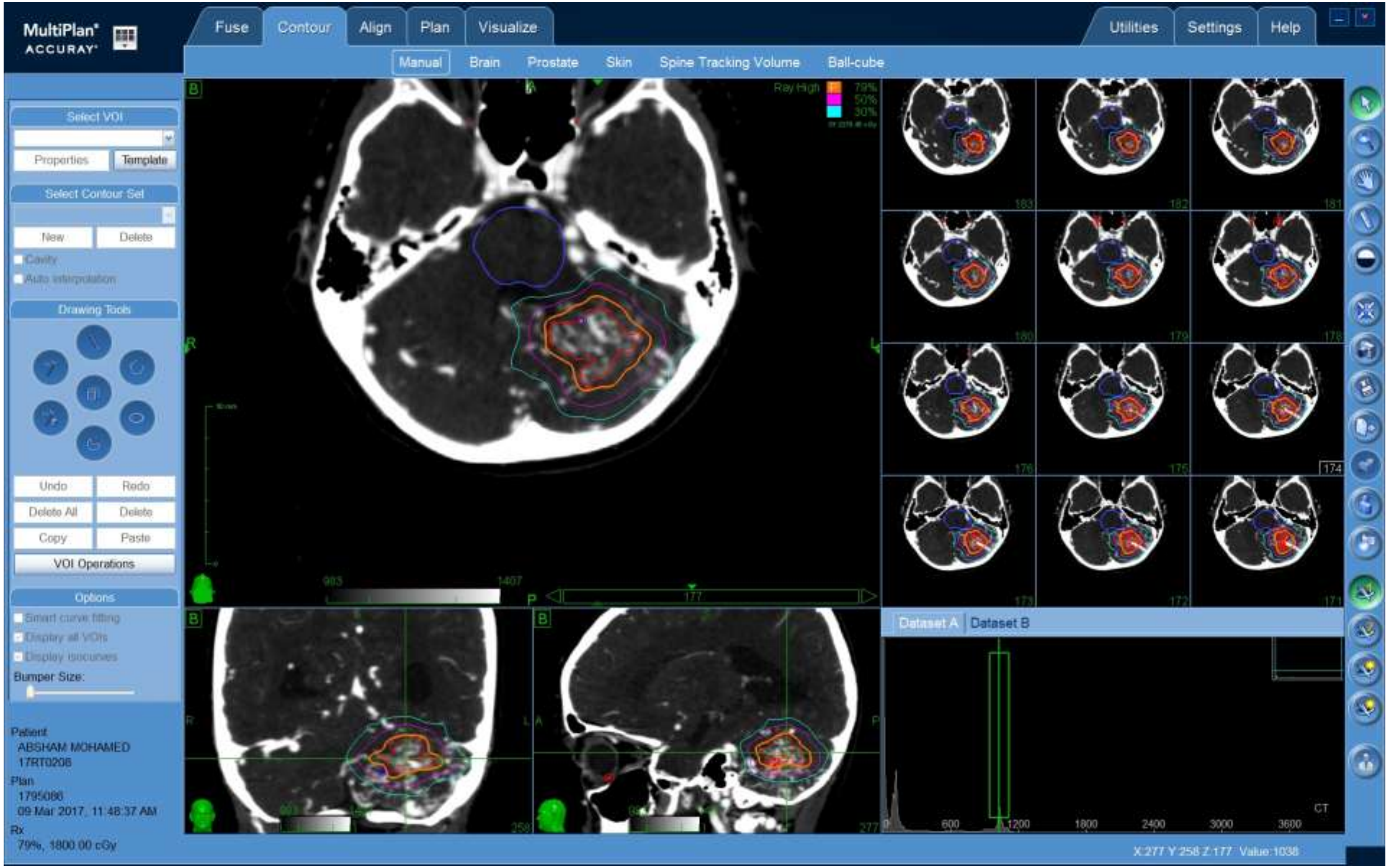
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Select VOI
Properties
Template
Select Contour Set
New
Delete
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Undo
Redo
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Display isocurves
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ABSHAM MOHAMED
17RT0208
Plan
1795086
09 Mar 2017, 11:48:37 AM
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79%
50%
30%
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Prospective Evaluation of Response to Treatment, Survival Functions, Recurrence Pattern and Toxicity Profile in Indian Patients with Oligo-Brain Metastasis Treated with Only SRS

Debnarayan Dutta, Sruti K. Reddy, Ram K. Kamath, Yarlagadda Sreenija, Haridas Nair, Ajay Sashidharan, Anoop Remesan Nair R, Pushpuja KU, Rajesh Kannan[1], Annex Edappattu[2], Nikhil K. Haridas[3], Wesley M. Jose[3], Pavithran Keechilat[3]

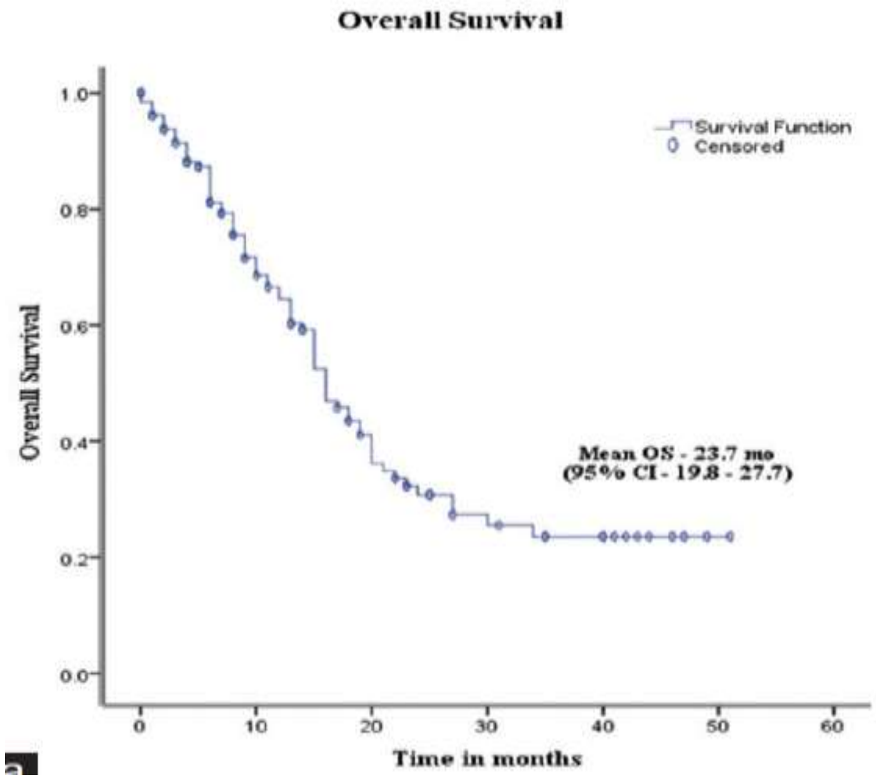


Table 3: Treatment outcome (*n*=132)

Follow-up mean (range) (mo)	15 (SD±11.9) Range: 0-56 months)	
Actuarial OS mean (range)	23.7 (SD±2) (95% CI: 20-28 months)	
Follow-up >3 months	124 (89.9%)	
Follow-up >6 months	108 (78.2%)	
Follow-up >12 months	65 (47%)	
Follow-up >24 months	26 (19%)	
Intracranial disease control status at last follow-up	Controlled	72 (52.2%)
	Progression	54 (39.1%)
	Not known	12 (8.7%)
Intracranial recurrence	54 (39.1%)	
	"In-field" recurrence	6 (11.1%)
	"Out-of-field" recurrence	23 (42.5%)
	In-field and out-of-field recurrence	25 (46.2%)
Status at last follow-up	Alive	55 (39.9%)
	Dead	75 (54.3%)
	Not known	8 (5.8%)

Dutta et al Neurol India 2023

Prospective study on Indian patients with brain mets treated with SRS only

Table 6: Prognostication based on grouping system

	Published patient cohort (*n*=214)				Our patient cohort (*n*=138)				
	Risk group (Score)	*n*	Survival% 6 mo	Survival% 12 mo	*n*	Mean OS (95% CI)	Survival% 6 mo	Survival% 12 mo	Survival% 24 mo
Prognostic group score	1 (17)	47 (22%)	36%	27%	9 (6.5%)	12.7(6.7-18.7)	89%	22.2%	22.2%
	2 (18-20)	120 (56%)	65%	44%	84 (60.8%)	23.3(18.6-28)	77.4%	51.1%	21.4%
	3 (21-22)	47 (22%)	80%	71%	45 (32.7%)	20.1 (14.9-25.3)	77.8%	44.4%	15.6%

Primary tumor type (breast ca 8, NSCLC 7, Melanoma 5, others 6); number of cerebral metastasis (1 lesion 7, 2-3 lesions 5); Extra-cerebral metastasis (No mets 7, mets 8) scores given and Risk groups (RG) considered (RG 1: 17; RG2: 18-20; RG3: 21-22)

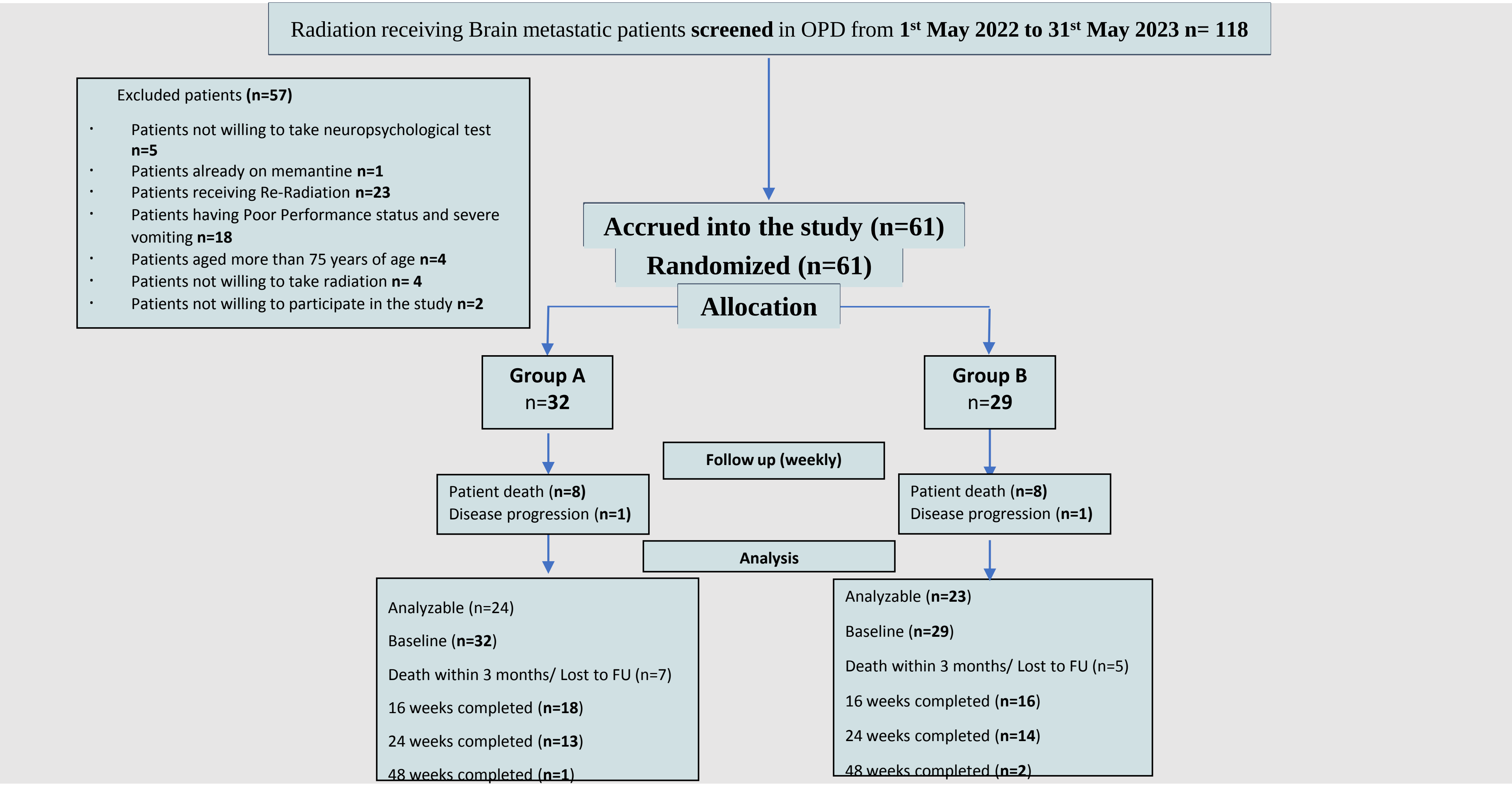
- Good prognostic group (Gr 2&3):
  Excellent correlation between Western patients & Indian patients
- Poor prognostic group (Gr 1):
  Poor correlation (less patient in Indian patient cohort)

Dutta et al Neurol India 2023

Huttenlocher S et al Radiat Oncol 2015

Study: Memantine for the Prevention of Radiation Induced Cognitive Dysfunction in Brain Metastatic Patients: A Randomized Placebo-Controlled Phase 3 Trial (CTRI /2022/ 01/ 039599)

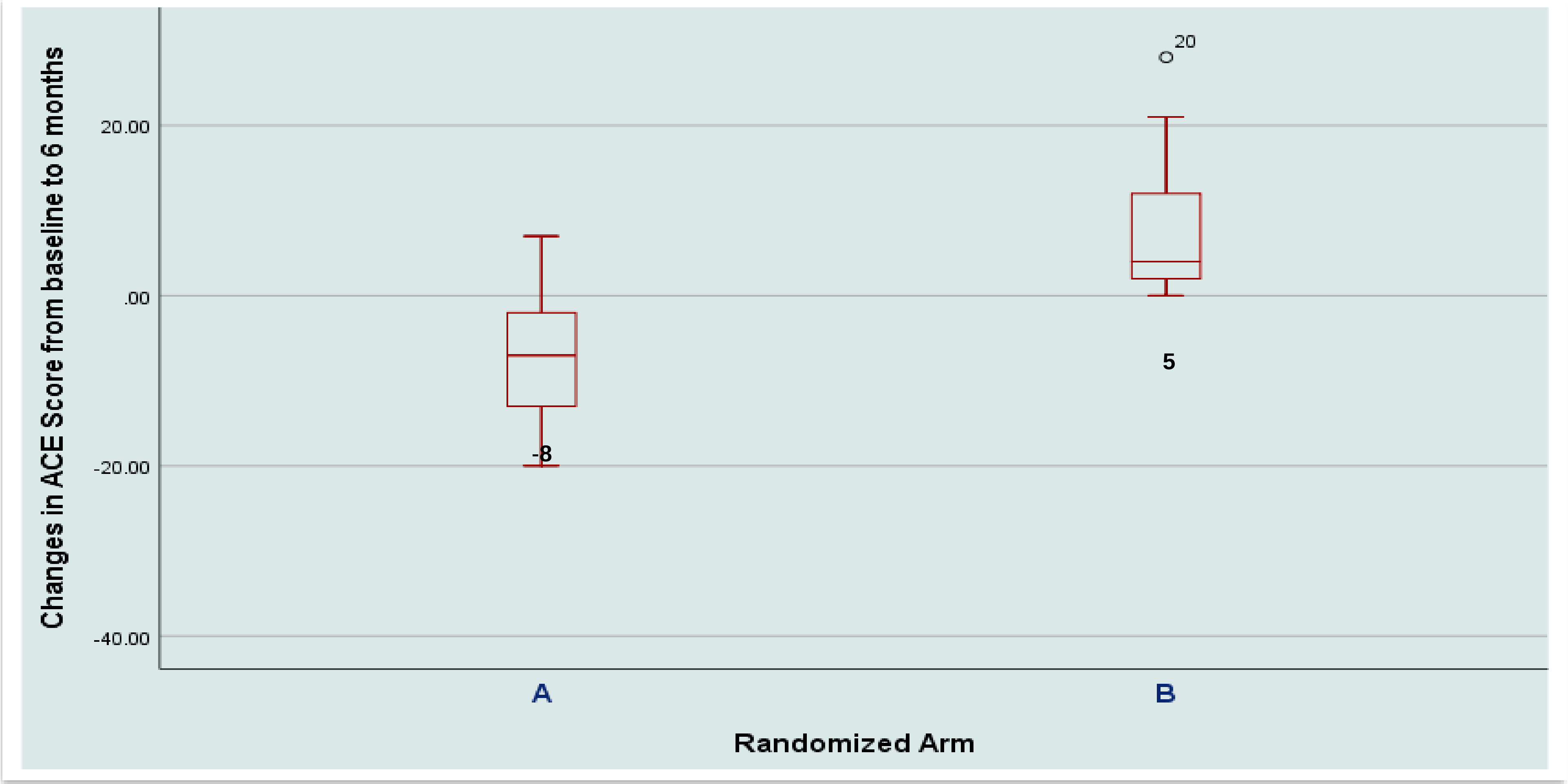
Estimated Sample Size: 186
Estimated completion: 2025



Institutional grant supported
CTRI/2022/01/039599

PI: Dr. D Dutta; Co-PI: Haripriya

NEUROCOGNITIVE OUTCOMES AT 6 MONTHS



SRS arm with memantine had significantly better preservation of cognitive function scores

ROJ Radiation Oncology Journal

Original Article

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Radiat Oncol J [Epub ahead of print]
https://doi.org/10.3857/roj.2023.00542

Validation of Combs prognostic scoring system in Indian recurrent glioma patients treated with re-radiation

Debnarayan Dutta[1,*], Meenu Jose[1,*], Sruthi Kalavagunta[1], Ajay Sasidharan[1], Haridas Nair[1], Annex H. Edappattu[2]

[1]*Department of Radiation Oncology, Amrita Institute of Medical Science, Kochi, Kerala, India*
[2]*Department of Medical Physics, Amrita Institute of Medical Science, Kochi, Kerala, India*

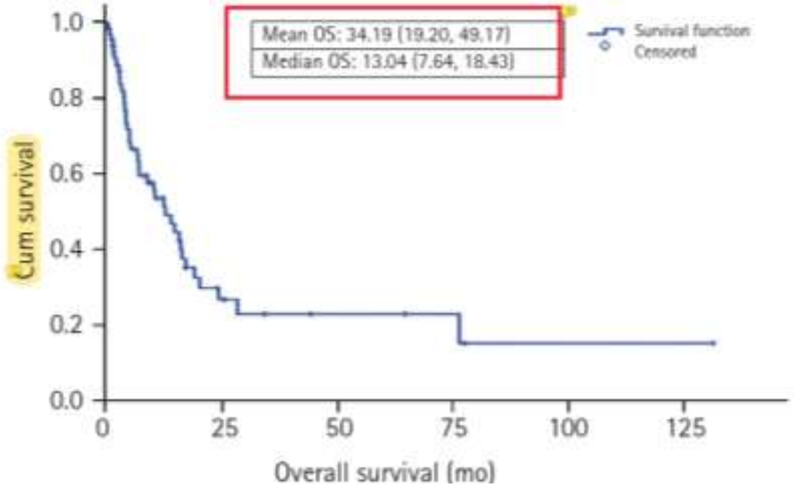

Table 3. Re-RT treatment and outcome parameters (n = 66)

Fractionation schedule	PTV (mL)		Dose (Gy)	OS (mo)
	Mean ± SD	Median (range)	Mean (range)	Mean (range)
Conventional fractionation (1.8–2 Gy/fx)	226.1 ± 140.7	180.0 (24.0–574.5)	50 (40–60)	18.8 (2.43–76.8)
Hypofractionation (2.2–4 Gy/fx)	162.8 ± 123.3	156.9 (27.5–387.9)	31 (20–40)	6.6 (2.0–17.4)
Ultra-hypofractionation (4–16 Gy/fx)	143.3 ± 145.8	84.6 (4.5–582.0)	20 (10–30)	13.9 (2.0–131.9)

Re-RT, reirradiation; PTV, planning target volume; SD, standard deviation.

Table 6. Survival function as per Combs scoring system

Group	Number of patients		Median OS (mo)		Proportion of patients surviving after							
					6 mo		12 mo		18 mo		24 mo	
	Our patient cohort (n = 66)	Combs cohort (n = 209)	Our patient cohort	Combs cohort	Our patient cohort	Combs cohort	Our patient cohort	Combs cohort	Our patient cohort	Combs cohort	Our patient cohort	Combs cohort
a	8	16	16.6	19.5	100	94	88	88	47	22	13	15
b	25	60	24.6	11.3	92	79	74	47	45	21	37	12
c	27	95	4.6	8.1	34	70	22	22	0	5	0	3
d	6	38	2	5.5	17	41	0	7	0	0	0	0

OS, overall survival.

Conclusions

- Brain radiosurgery have long history of more than 50 years
- The indications for radiosurgery in brain lesions are defined with multiple long term and large prospective series
- Linac based SRS systems help in expanding the indications in larger lesions

- Contouring is the most important step in radiosurgery
- Treatment delivery need to be monitored

- Plan evaluation and prescription criteria are different in radiosurgery
- Response assessment schedules and goal depends upon indications

- There are many scopes for further exploration in radiosurgery

Abnormal olfactory perception during stereotactic radiation therapy using Cyberknife for primary brain tumor: A case study

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Department of Radiation Oncology, Amrita Institute of Medical Science, Kochi, Kerala, India
Department of Radiation Technology, Amrita Institute of Medical Science, Kochi, Kerala, India
Department of Medical Physics, Amrita Institute of Medical Science, Kochi, Kerala, India

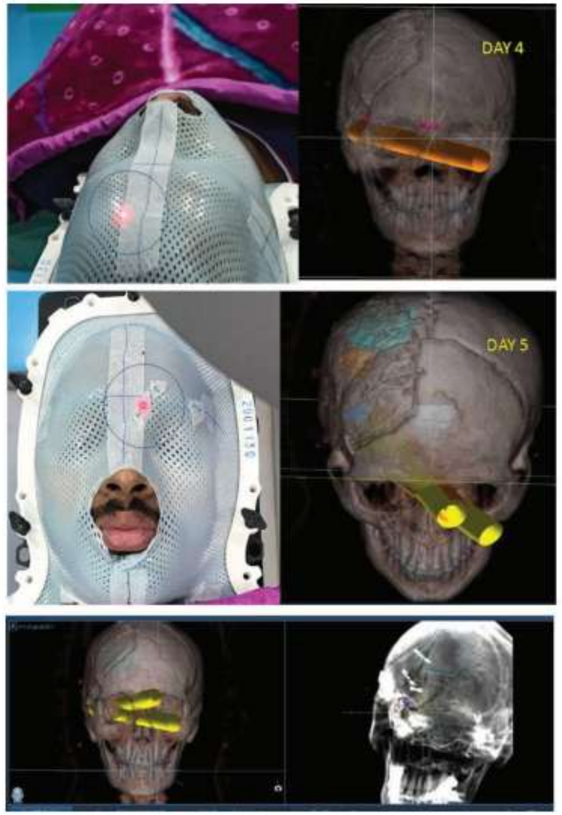

Figure 1. Details of beam delivery with altered odor sensation.

Verma et al, JSBRT 2022