ACADEMIC QUALIFICATIONS

MBBS	**MYSORE MEDICAL COLLEGE**	1996
MD	**BANARAS HINDU UNIVERSITY**	2002
DNB	NATBOARD	2003
MNAMS	**AIIMS**	2005

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>150 INDEXED PUBLICATIONS
>100 MEETING ABSTRACTS
>100 PRESENTATIONS IN INTERNATIONAL AND NATIONAL MEETINGS

LEADERSHIP IN GOVERNING BODIES

Editorial board of JCRT
Joint Secretary AROI
Secretary - Neuro Oncology society, Bangalore
Joint Secretary- Bangalore Oncology Group
Secretary-Indian Association of Hyperthermia Oncology
Advisory to GE health care

Insight to Radiation techniquesfor CNS tumors-SRS/SRT-Gammaknife,Xknife,Cyberknife

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Introduction SRS/SRT

Gamma knife,X knife, Cyberknife

Robotic radiosurgery-CYBERKNIFE

Cases

INTRODUCTION

- Stereotactic radiosurgery and radiotherapy are techniques to administer *precisely directed*, ***high-dose irradiation*** that ***tightly conforms*** to a ***target*** to create a *desired radiobiologic response* while *minimizing radiation dose to surrounding normal tissue.*

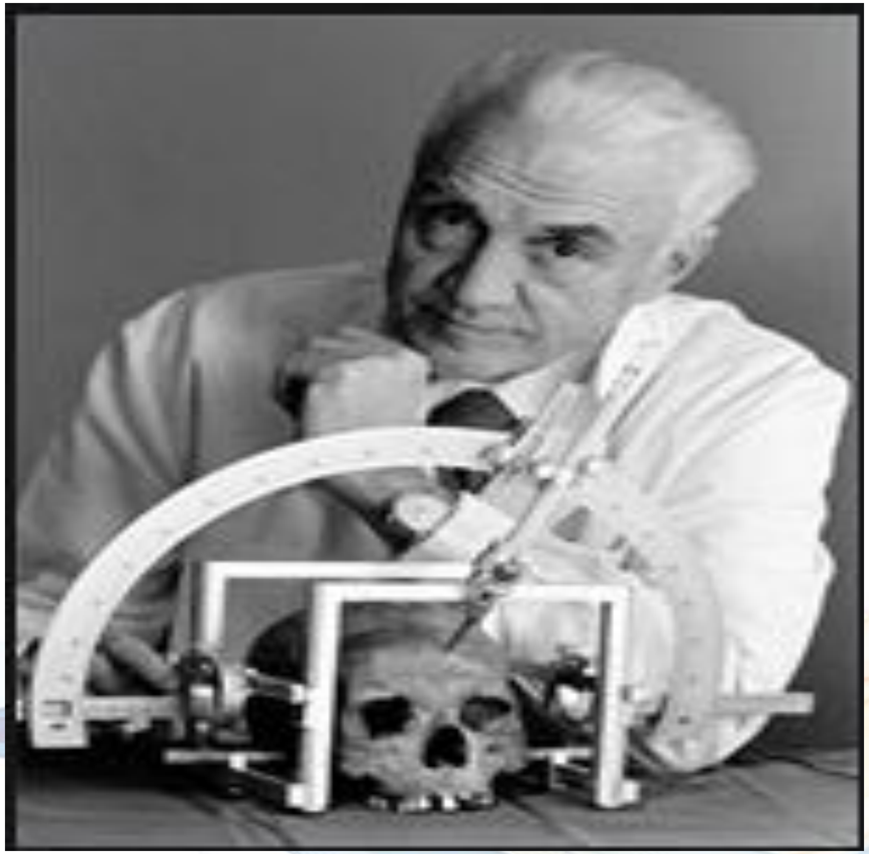
KEY REQUIREMENTS FOR OPTIMAL STEREOTACTIC IRRADIATION

REQUIREMENT	RATIONALE
Small target/treatment volume	Reducing the volume of normal and target tissues irradiated to high doses improves tolerance
Sharply defined target	Can be treated with little or no extra margin of sorrounding normal tissue and/or without unintentional underdosage of the target (marginal miss)
Accurate radiation delivery	No margin of normal tissue needed for setup error and/ or reduced chance of underdosing target
High conformality	Reduces the treatment volume to match the target volume
Sensitive structures excluded from target	Dose limiting structures (optic chiasma/spinal cord) should be able to be defined and excluded from the target volume to limit the risk of radiation injury

RADIOTHERAPY FRACTIONATION SCHEDULES

Fractionation Schedule	Dose/Fx (Gy)	# of Fx/Wk	Total Dose Gy	Overall Time
Conventional	**1.5-2.5**	**5-6**	**60-75**	**6-10 weeks**
Hyper	↓	↑	↑	↓ or same
Accelerated	↓	↑	↓ or same	↓
Hypo	↑	↓	↓ or same	↓ or same

History of Stereotactic Radiosurgery



Dr.Lars Leksell, Neurosurgeon. He was the inventor radiosurgery, Karolina Institute in Sweden.

Leksell installed the first gamma unit in Stockholm in 1968.

SRS and SBRT Equipment

- Commonly used SRS and SBRT machine classified into three categories:
  - Gamma ray System
  - Linear accelerator(Linac) system.
  - Proton or Heavy charged particle system.

Gamma System

- Gamma Knife System used 192 or 201 cobalt source all aiming at the treatment target.

- Gamma ray system have used 30 rotating 30 cobalt source to treat SRS & SBRT small tumors.

- This gamma ray system uses imaging guidance which will help us to treat extra cranial also.

Linear Accelerators

- Linac Machine can be used to perform the SRS SBRT Procedure using cone or MLC.

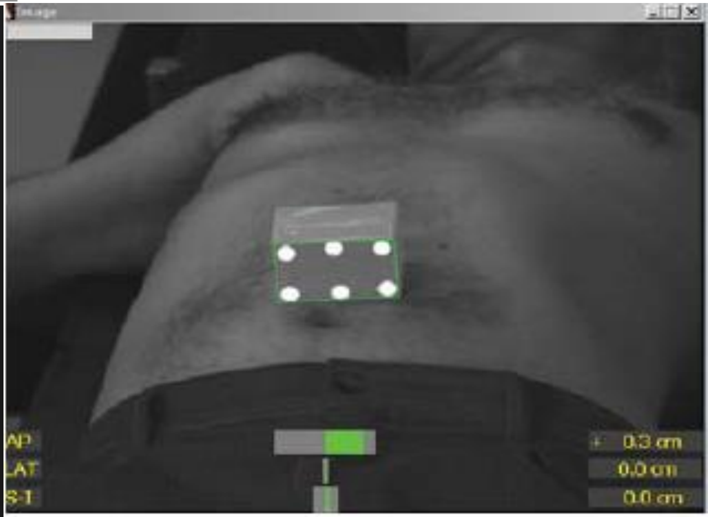
- Several Machine provide the SRS & SBRT treatment e.g Cyber Knife, Novalis TX, True beam, Tomotherapy, Versa HD etc

- Proton or Heavy Charged particle system can be used for SRS & SBRT

Linear Accelerators & Gamma unit

Also

- Excellent Immobilization,
- High Level Image Guidance,
- High Precision Delivery,
- Relatively small field sizes,
- Many Beams or Arcs,
- Motion Management
- Brain mask Thickness should be less than2.4mm



Treatment Planning and Optimization for SRS and SBRT

- Unlike conventional RT which deliver Uniform dose, the dosimetric requirement for SRS and SBRT are different in two aspects,

  - A small target volume containing Gross tumor & close vicinity is treated with high dose per fraction with heterogeneous dose distribution(hot spots).

  - The normal tissue volume outside treatment volume which requires a step dose fall-off away from target

Simulation Imaging

- SRS, SBRT requires precise delineation of patient anatomy, targets for planning and clear visualization for localization during delivery.
- CT, CETCT, 4DCT, MRI and PET images assist in target delineation.
- CT is the primary imaging modalities basis for treatment planning calculations.
- MR is gold standard for visualization of brain SRS and increasingly used in SBRT like Prostate, spinal tumors.
- PET is widely used in lung, head neck, colon cancer etc.

Definition of Target volume and Critical Structure

➢ Target Volume:

- The success of radiation therapy depends on the precise knowledge of the target and surrounding critical structures.
- Three main Volume have been defined for RT:
  - ➢ GTV-Gross tumor Volume
  - ➢ CTV-Clinical Target Volume
  - ➢ PTV- Planning target volume (used to account for random and systematic uncertainties planning & dose delivery).

Continue,

- For some body sites that are affected by respiration motion such as lung or liver tumor, internal margin is added to CTV to compensate for internal movement and variation of tumor position, shape & size. This is referred as Internal Target volume(ITV).
- Currently four dimensional computed (4DCT) is being used to generate ITV either by delineating the target volumes on CT images at 10 breathing phase or single maximum intensity projection(MIP) image.
- An isotropic 5mm ITV-PTV margin has been used by many institution for Linac–Based Lung SBRT with 4D imaging. However, this margin should be based on equipment and institutional experience

Organ at Risk.

- An important goal of treatment planning is to avoid radiation damage to critical organs and normal structures known as Organ at risk(OAR).
- OARs are delienated and some case safety margin added to around an OAR to account for random and systemic error.
- This is referred to as planning risk volume (PRV). E.g. serial organ

Dose Calculation

- Dose calculation in a challenging environment
  - small field size
  - target surrounded by low density tissue
- There are three type of dose calculation algorithm used in commonly used in TPS';
  - Correction- Based algorithm-conventional / involded minimal computation

  - Model- Based algorithm (AAA,CCC, Acuros XB, FSPB etc)

  - Monte carlo algorithm

Dosimeteric parameters for plan Evaluation

- Target Dose coverage
- Target Dose Heterogeneity
- Conformity index
- High dose spillage
- Intermediate dose spillage or Gradient Index

Target Coverage

- The target dose is can be normalized to prescribe the dose to either 50% or more for intracranial SRS or 60-80% for Isodose for SBRT to achieve a 95% or higher coverage of target volume.
- Another important target dose requirement is at least 99% of PTV should receive more than 90% prescription dose(allowing a cold spot <10%)

- This result in a Dmax up to 200% of prescription dose for SRS or 130-170% dose for SBRT, Which must be inside the target volume.

Conformity Index

- The conformity index defined as ratio of prescription Isodose volume to PTV volume
- CI = PI/ PTV
- PI-Prescription Isodose volume
- PTV- Planning Target volume
- Ideal CI Should be 1
- Its recommended that this ratio be kept to less than 1.2 to minimize the volume of tissue receiving ablative dose
- Greater CI (e.g., up to 1.5) may be used for small tumors (<2.5cm).

Target Dose Heterogeneity

- For SRS and SBRT the prescription dose is often specified at lower Isodose, e.g. 50% for SRS and 60%-80% for SBRT , Because of the ablative nature of SRS and SBRT, sharper dose fall-offs outside of the treatment target is required to avoid damaging nearby OARs. Thus, the prescription dose is specified to lower Isodose lines compromise between dose fall-off and target dose heterogeneity.

Brain

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adding life to years

- For brain metastases, with median minimum peripheral doses of 16.5-25Gy. Up to 5 lesions can be treated at one time. A whole brain irradiation can be given before or after the SRS treatment.
- Prescription doses for other diseases:
- SRS 16.5-20Gy for AVM
- SRS 15-20Gy and SRT 45-50Gy for pituitary adenoma;
- SRS 10-12.5Gy and SRT 20-25Gy for acoustic schwannomas SRS/ SRT 10-50Gy for meningioma-
- SRS 70-80 Gy for trigeminal neuralgia
- 120-180Gy for thalamotomy, and 120-160Gy Parkinsons disease, Movement disorders

Volume-dose constraints and the maximum point doses (volume <0.035cc) for various organs for a single-fraction SRS treatment

Tissue/Organ	Volume	Volume Max Dose	Max Point Dose
Optic pathway	<0.2 cc	8 Gy	10 Gy
Cochlea			9 Gy
Brainstem (not medulla)	<0.5 cc	10 Gy	15 Gy
Spinal cord and medulla (10cm above and below treatment target)	<0.35 cc <1.2 cc	10 Gy 8 Gy	14 Gy
Spinal cord subvolume (5–6mm above and below treatment target)	<10%	10 Gy	14 Gy
Cauda equina	<5 cc	14 Gy	16 Gy
Sacral plexus	<5 cc	14.4 Gy	16 Gy
Esophagus	<5 cc	11.9 Gy	15.4 Gy
Brachial plexus	<3 cc	13.6 Gy	16.4 Gy
Heart/pericardium	<15 cc	16 Gy	22 Gy
Great vessels	<10 cc	31 Gy	37 Gy
Trachea and large bronchus	<4 cc	17.4 Gy	20.2 Gy
Bronchus- smaller airways	<0.5 cc	12.4 Gy	13.3 Gy
Lung (right & left)	1500 cc	7 Gy	
Lung (right & left)	1000 cc	7.6 Gy	V_{8Gy} <37%
Rib	<5 cc	28 Gy	33 Gy
Skin	<10 cc	25.5 Gy	27.5 Gy
Stomach	<5 cc	17.4 Gy	22 Gy
Bile duct			30 Gy
Duodenum	<5 cc <10 cc	11.2 Gy 9 Gy	17 Gy
Liver	700 cc	11 Gy	
Renal cortex (right & left)	200 cc	9.5 Gy	
Jejunum/ileum	<30 cc	12.5 Gy	22 Gy
Colon	<20 cc	18 Gy	29.2 Gy
Rectum	<3.5 cc <20 cc	39 Gy 22 Gy	44.2 Gy
Ureter			35 Gy
Bladder wall	<15 cc	12 Gy	25 Gy
Penile bulb	<3 cc	16 Gy	
Femoral heads	<10 cc	15 Gy	
Renal hilum/vascular trunk	15 cc	14 Gy	

3 fraction SRT SBRT treatment

Tissue/Organ	Volume	Volume Max Dose	Max Point Dose
Optic pathway	<0.2 cc	15.3 Gy	17.4 Gy
Cochlea			14.4 Gy
Brainstem (not medulla)	<0.5 cc	15.9 Gy	23.1 Gy
Spinal cord and medulla (10cm above and below treatment target)	<0.35 cc <1.2 cc	15.9 Gy 13 Gy	22.5 Gy
Spinal cord subvolume (5-6mm above and below treatment target)	<10%	18 Gy	22.5 Gy
Cauda equina	<5 cc	21.9 Gy	25.5 Gy
Sacral plexus	<5 cc	22.5 Gy	24 Gy
Esophagus	<5 cc	17.7 Gy	25.2 Gy
Brachial plexus	<3 cc	22 Gy	26 Gy
Heart/pericardium	<15 cc	24 Gy	30 Gy
Great vessels	<10 cc	39 Gy	45 Gy
Trachea and large bronchus	<5 cc	25.8 Gy	30 Gy
Bronchus- smaller airways	<0.5 cc	18.9 Gy	23.1 Gy
Lung (right & left)	1500 cc	10.5 Gy	
Lung (right & left)	1000 cc	11.4 Gy	V_{11Gy}<37%
Rib	<5 cc	40 Gy	50 Gy
Skin	<10 cc	31 Gy	33 Gy
Stomach	<5 cc	22.5 Gy	30 Gy
Bile duct			36 Gy
Duodenum	<5 cc <10 cc	15.6 Gy 12.9 Gy	22.2 Gy
Liver	700 cc	17.1 Gy	
Renal cortex (right & left)	200 cc	15 Gy	
Jejunum/ileum	<30 cc	17.4 Gy	27 Gy
Colon	<20 cc	24 Gy	34.5 Gy
Rectum	<3.5 cc <20 cc	45 Gy 27.5 Gy	49.5 Gy
Ureter			40 Gy
Bladder wall	<15 cc	17 Gy	33 Gy
Penile bulb	<3 cc	25 Gy	
Femoral heads	<10 cc	24 Gy	
Renal hilum/vascular trunk	15 cc	19.5 Gy	

5 &8 fraction SRT SBRT treatment

Tissue/Organ	Volume	Volume Max Dose	Max Point Dose
Optic pathway	<0.2 cc	23 Gy	25 Gy
Cochlea			22 Gy
Brainstem (not medulla)	<0.5 cc	23 Gy	31 Gy
Spinal cord and medulla (10cm above and below treatment target)	<0.35 cc <1.2 cc	22 Gy 15.6 Gy	28 Gy
Spinal cord subvolume (5-6mm above and below treatment target)	<10%	22 Gy	28 Gy
Cauda equina	<5 cc	30 Gy	31.5 Gy
Sacral plexus	<5 cc	30 Gy	32 Gy
Esophagus	<5 cc	19.5 Gy	35 Gy
Brachial plexus	<3 cc	27 Gy	32.5 Gy
Heart/pericardium	<15 cc	32 Gy	38 Gy
Great vessels	<10 cc	47 Gy	53 Gy
Trachea and large bronchus	<5 cc	32 Gy	40 Gy
Bronchus- smaller airways	<0.5 cc	21 Gy	33 Gy
Lung (right & left)	1500 cc	12.5 Gy	
Lung (right & left)	1000 cc	13.5 Gy	$V_{13.5Gy}$<37%
Rib	<5 cc	45 Gy	57 Gy
Skin	<10 cc	36.5 Gy	38.5 Gy
Stomach	<5cc	26.5 Gy	35 Gy
Bile duct			41 Gy
Duodenum	<5 cc <10 cc	18.5 Gy 14.5 Gy	26 Gy
Liver	700 cc	21 Gy	
Renal cortex (right & left)	200 cc	18 Gy	
Jejunum/ileum	<30 cc	20 Gy	32 Gy
Colon	<20 cc	28.5 Gy	40 Gy
Rectum	<3.5 cc <20 cc	50 Gy 32.5 Gy	55 Gy
Ureter			45 Gy
Bladder wall	<15 cc	20 Gy	38 Gy
Penile bulb	<3 cc	30 Gy	
Femoral heads	<10 cc	30 Gy	
Renal hilum/vascular trunk	15 cc	23 Gy	

Tissue/Organ	Volume	Volume Max Dose	Max Point Dose
Optic pathway	<0.2 cc	27.2 Gy	29.6 Gy
Cochlea			26.4 Gy
Brainstem (not medulla)	<0.5 cc	27.2 Gy	37.6 Gy
Spinal cord and medulla (10cm above and below treatment target)	<0.35 cc <1.2 cc	26.4 Gy 18.2 Gy	33.6 Gy
Spinal cord subvolume (5-6mm above and below treatment target)	<10%	26.4 Gy	33.6 Gy
Cauda equina	<5 cc	36 Gy	38.4 Gy
Sacral plexus	<5 cc	36 Gy	38.4 Gy
Esophagus	<5 cc	21.6 Gy	38.4 Gy
Brachial plexus	<3 cc	32.8 Gy	39.2 Gy
Heart/pericardium	<15 cc	34.4 Gy	38.4 Gy
Great vessels	<10 cc	55.2 Gy	38.4 Gy
Trachea and large bronchus	<5 cc	38.4 Gy	48.8 Gy
Bronchus- smaller airways	<0.5 cc	22.4 Gy	36 Gy
Lung (right & left)	1500 cc	13.6 Gy	
Lung (right & left)	1000 cc	15.2 Gy	V_{15Gy}<37%
Rib	<5 cc	50 Gy	63 Gy
Skin	<10 cc	43.2 Gy	45.6 Gy
Stomach	<5 cc	31.2 Gy	42 Gy
Bile duct			48 Gy
Duodenum	<5 cc <10 cc	21 Gy 16 Gy	30.4 Gy
Liver	700 cc	24 Gy	
Renal cortex (right & left)	200 cc	21 Gy	
Jejunum/ileum	<30 cc	23.2 Gy	37 Gy
Colon	<20 cc	33 Gy	48 Gy
Rectum	<3.5 cc <20 cc	58.4 Gy 37.5 Gy	63.2 Gy
Ureter			53 Gy
Bladder wall	<15 cc	22.4 Gy	44.8 Gy
Penile bulb	<3 cc	35	
Femoral heads	<10 cc	35 Gy	
Renal hilum/vascular trunk	15 cc	28 Gy	

	CyberKnife®	Gamma Knife®	Other Linac Systems (Elekta Synergy®, Novalis®, Varian Trilogy®, TomoTherapy®)
Radiosurgery Dedicated	Yes	Yes	No
Also Does "Conventional" Radiotherapy	No	No	Yes
Anatomic Area treatable with Radiosurgical Precision	Brain, Spine, Entire Body	Brain	Brain +/- other selected sites depending upon specific system
Rigid Brain or Body Frame Required for Radiosurgical Accuracy	No	Yes	Yes
Lesion Size Limitation	No	Yes	No
Capable of divided treatments to better preserve adjacent tissues	Yes	No	Yes
Continuously adapts to lesion motion caused by organ movement (real time lesion tracking)	Yes	N/A	No
Continuously adapts to lesion motion caused by breathing (real time respiratory tracking)	Yes	N/A	Varian Trilogy® uses respiratory gating but does not track with radiosurgical precision – Other systems do not adapt to breathing

Cyberknife

6 MV, 800 mu/min, compact linac

Industrial robot, 0.2 mm repeatability

Aperture sizes: 3,5, 7.5, 10, 12.5, 15, 20, 25, 30, 35, 40, 50, 60 mm

Fixed cones or adjustable iris collimator

2 diagnostic x-ray sources

- Patient imaged at 45 orthogonal angles
- 2 amorphous silicon detectors, 512x512 pixels,

20 x 20 cm2 FOV

During treatment robot adjusts position based on comparison of live images with DRRs

- Sub-millimeter targeting accuracy

CYBERKNIFE

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CyberKnife®
ACCURAY®

PATIENT WORKFLOW

CYBERKNIFE

CYBERKNIFE


Synchrony® Respiratory Tracking System
radiosurgery using the synchrony respiratory

Cyberknife Image Guided Target Tracking

6D Skull
XSight Spine
Fiducial
Synchrony
XSight Lung
4D

CyberKnife:

Frameless,
Single/Fractionated,
Image Guided,
Real time Tracking,
Sterotactic,
(whole)
Body Radiotherapy/Radiosurgery
(SBRT/SRS)

All in one

ESTABLISHED INDICATIONS

BENIGN TUMOUR

- Meningioma
- Pituitary adenoma
- Acoustic Neuromas and other cranial nerve schwannomas
- CP angle tumors
- Peripheral nerve sheath tumours
- Paragangliomas [carotid body tumours, glomous jugulare]
- Craniopharyngioma
- Pinealoma
- Pineoblastoma
- Pineocytoma

MALIGNANT TUMOURS

DEFINITIVE/ RE-IRRADIATION

- LUNG
- PANCREAS
- PROSTATE
- LIVER
- HEAD AND NECK
- SKULL BASE TUMORS
- BRAIN TUMORS
    - Gliomas
    - Medulloblastoma

METASTATIC DISEASE

- BRAIN METASTASES
- SPINAL METASTASES
- LUNG METASTASES
- LIVER METS
- BONE METS
- ADRENAL METS

FUNCTIONAL

- Trigeminal neuralgia/Epilepsy/Psychiatric disorders

VASCULAR

- Arteriovenous Malformations
- Cavernous malformations
- Arterial aneurysm
- Carotid-cavernous fistula
- Cavernous angioma
- Choroid plexus papilloma
- Ependymoma
- Glomus tumor
- Hemangioblastoma

POTENTIAL INDICATIONS

Boost to EBRT

- Gliomas
- Nasopharyngeal carcinoma
- Lung cancer
- Prostate cancer
- Head and neck cancer

INNOVATIVE

- Large volume tumors
- Hyperfunctioning endocrine tumors
- Neoadjuvant settings in unresectable or moderately resectable tumors
- CK -> EBRT-> CK
- Functional – Schizophrenia/Tremors/OCD

CYBERKNIFE-12 years

30/05/09-30/05/19

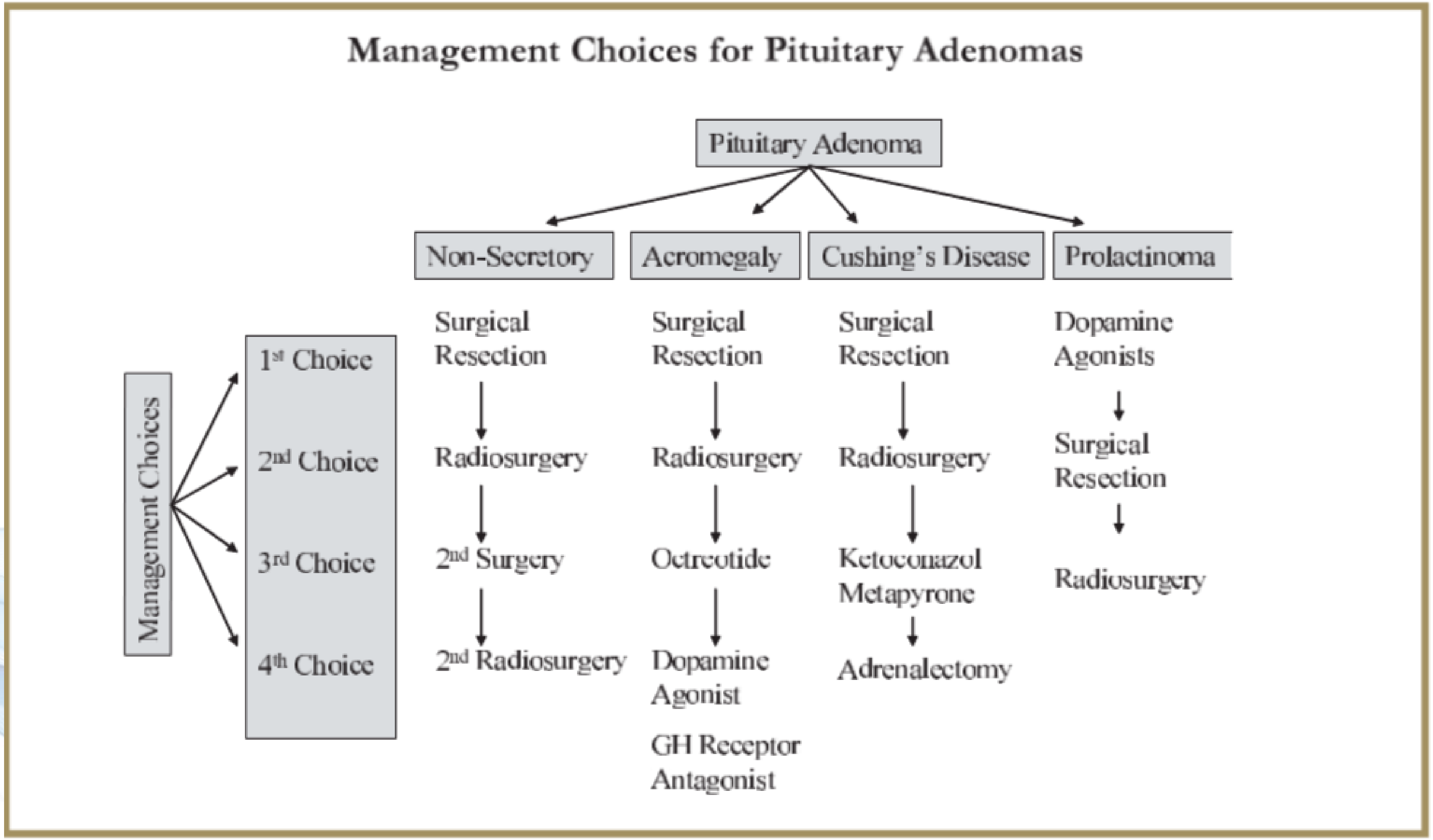
Total – 3840

Extracranial-2389

Intracranial-1451

BENIGN TUMORS

IRSS guidelines



Pituitary adenoma

- 84 cases (F-38,M-46)
- 79 post op residual/recurrence
- 15 immediate post op
- 5 primary
- 10 Functional

HCG –Pituitary Protocol

- DOTA PET
- MRI
- Hormone assay
- Perimetry

HCG protocol..

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- <2 cms – 10-14Gy/1Fr
- >2 cm,Optic apparatus, Recurrent/Reirradiation – 18Gy/3Fr,25Gy/5Fr

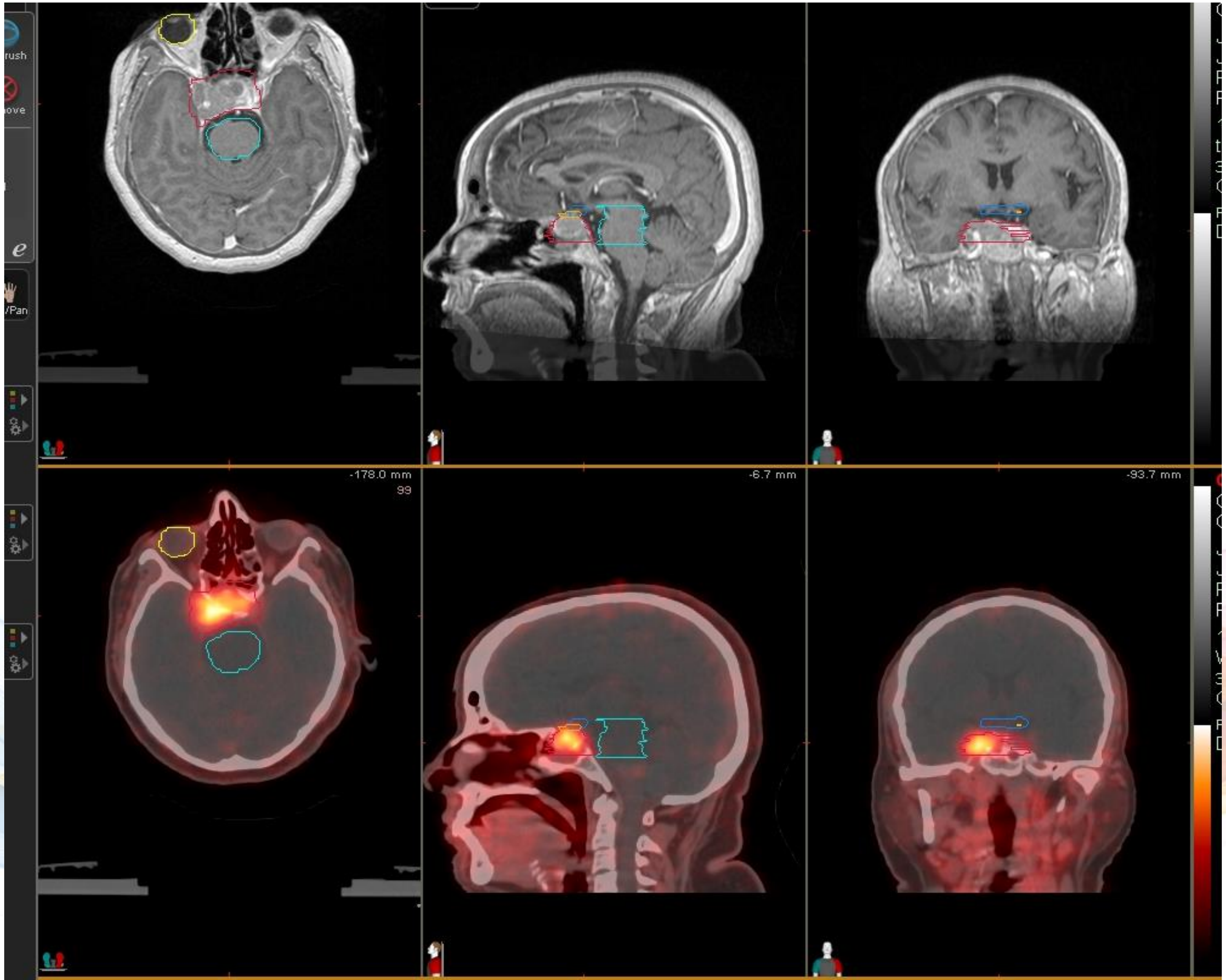
Target delineation and optimal radiosurgical dose for pituitary tumors

- Giuseppe Minniti[1, 2]Email author,
- Mattia Falchetto Osti[1] and
- Maximillian Niyazi[3]

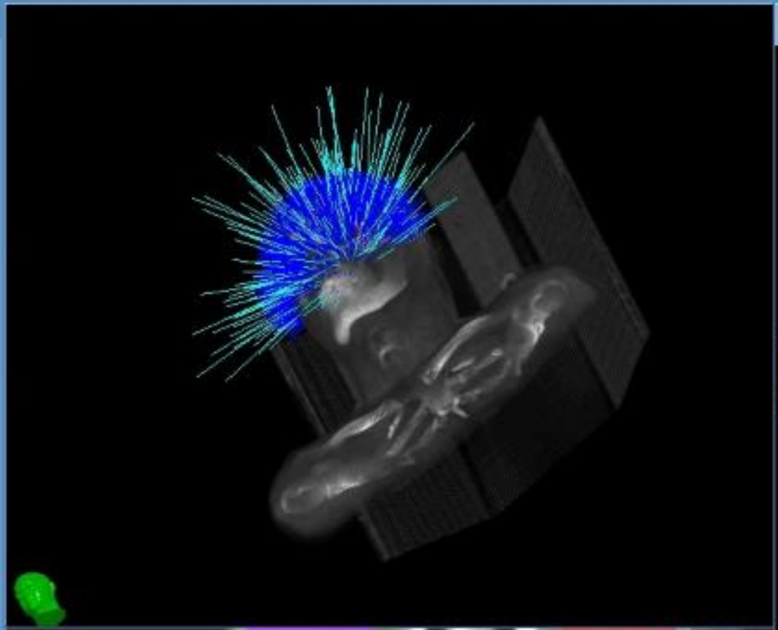
Radiation Oncology201611:135

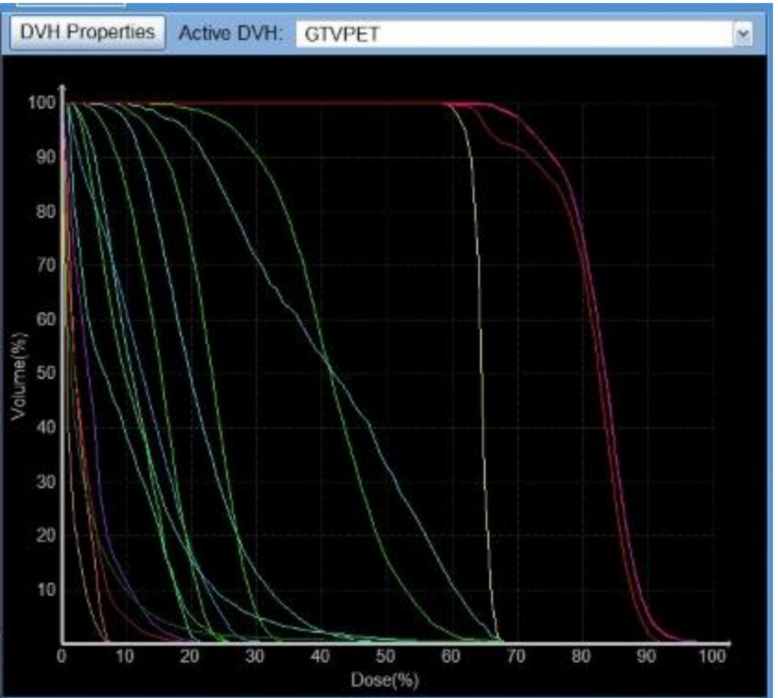
DOI: 10.1186/s13014-016-0710-y

45 yrs/f, recurrent pituitary adenoma



45yrs/M

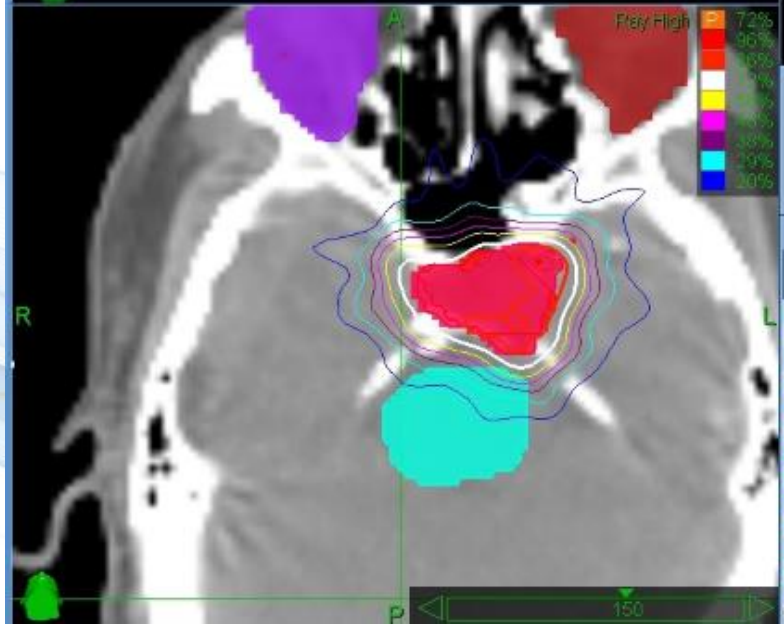




Nodes	102	Total MU	35630.52
Beams	208	Min MU	5.50
Max Dose (cGy)	3472.22	Max MU	426.88

Dose Statistics Table

VOI	Min (cGy)	Mean (cGy)	Max (cGy)	CI	nCI	HI	Coverage
GTVMR1	2030.19	2875.00	3472.22	1.63	1.72	1.39	95.03
GTVMR2	2072.31	2236.87	2348.35	0.00	0.00	1.39	0.00
OC	360.23	1433.40	2441.55	n/a	n/a	n/a	n
RTON	77.46	369.51	936.31	n/a	n/a	n/a	n
LT ON	38.20	289.26	740.33	n/a	n/a	n/a	n
OAR1	43.71	440.36	1237.15	n/a	n/a	n/a	n
5MM_OUT	475.63	1438.53	2667.20	n/a	n/a	n/a	n
10MM_OUTER	289.18	790.52	1310.16	n/a	n/a	n/a	n
15MM_OUT	121.65	521.07	969.05	n/a	n/a	n/a	n
OAR2	170.87	732.36	1940.76	n/a	n/a	n/a	n
BRAIN STEM	65.17	456.87	2595.20	n/a	n/a	n/a	n
LT ORBIT	10.12	115.09	1094.89	n/a	n/a	n/a	n
RT ORBIT	14.36	171.70	924.23	n/a	n/a	n/a	n



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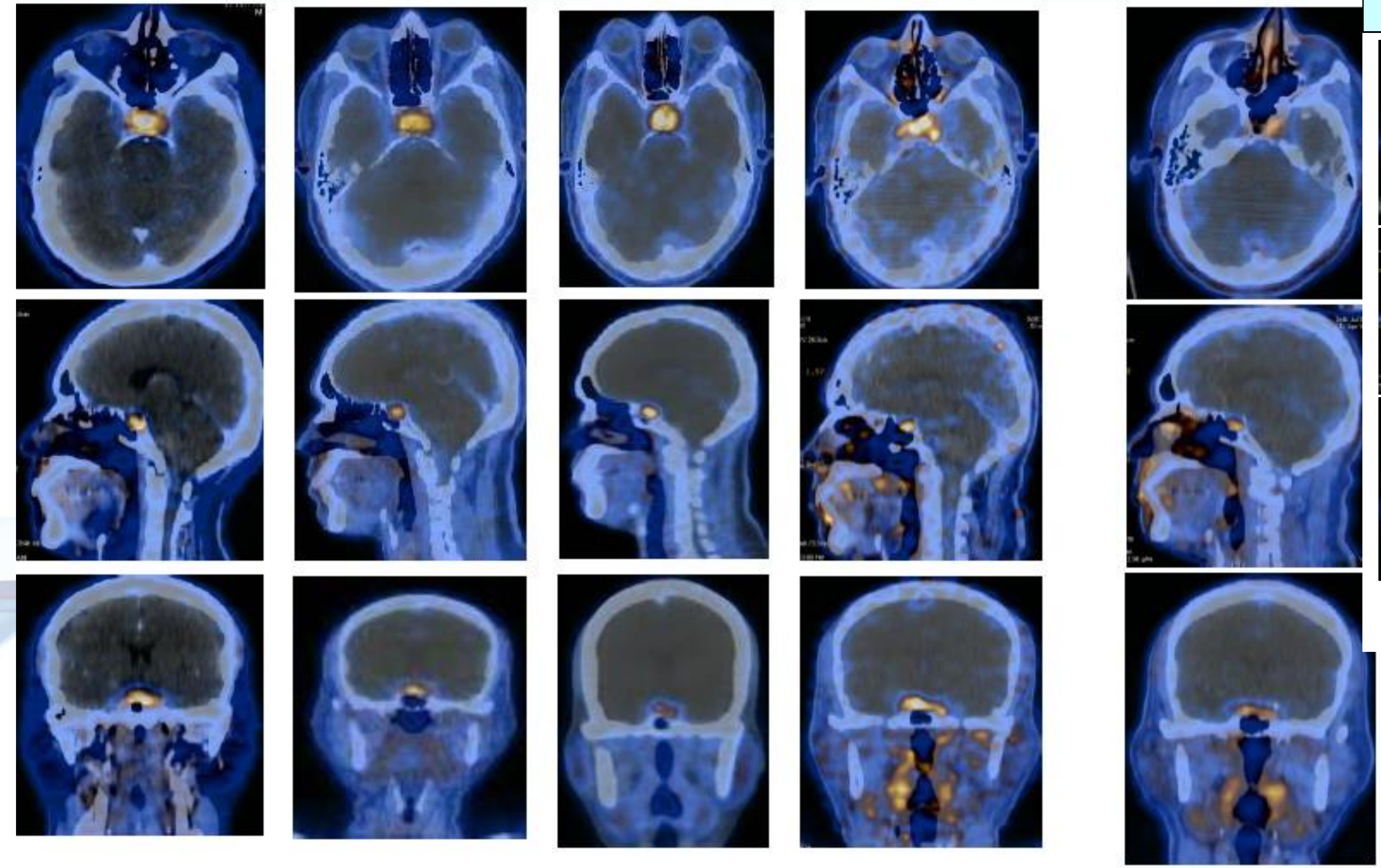
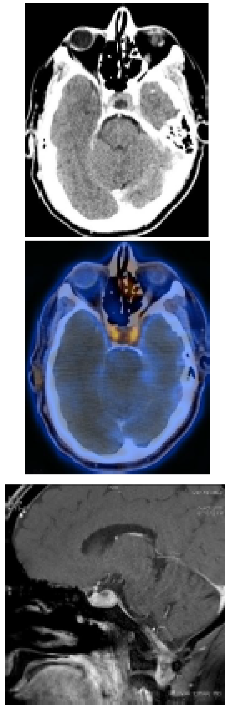
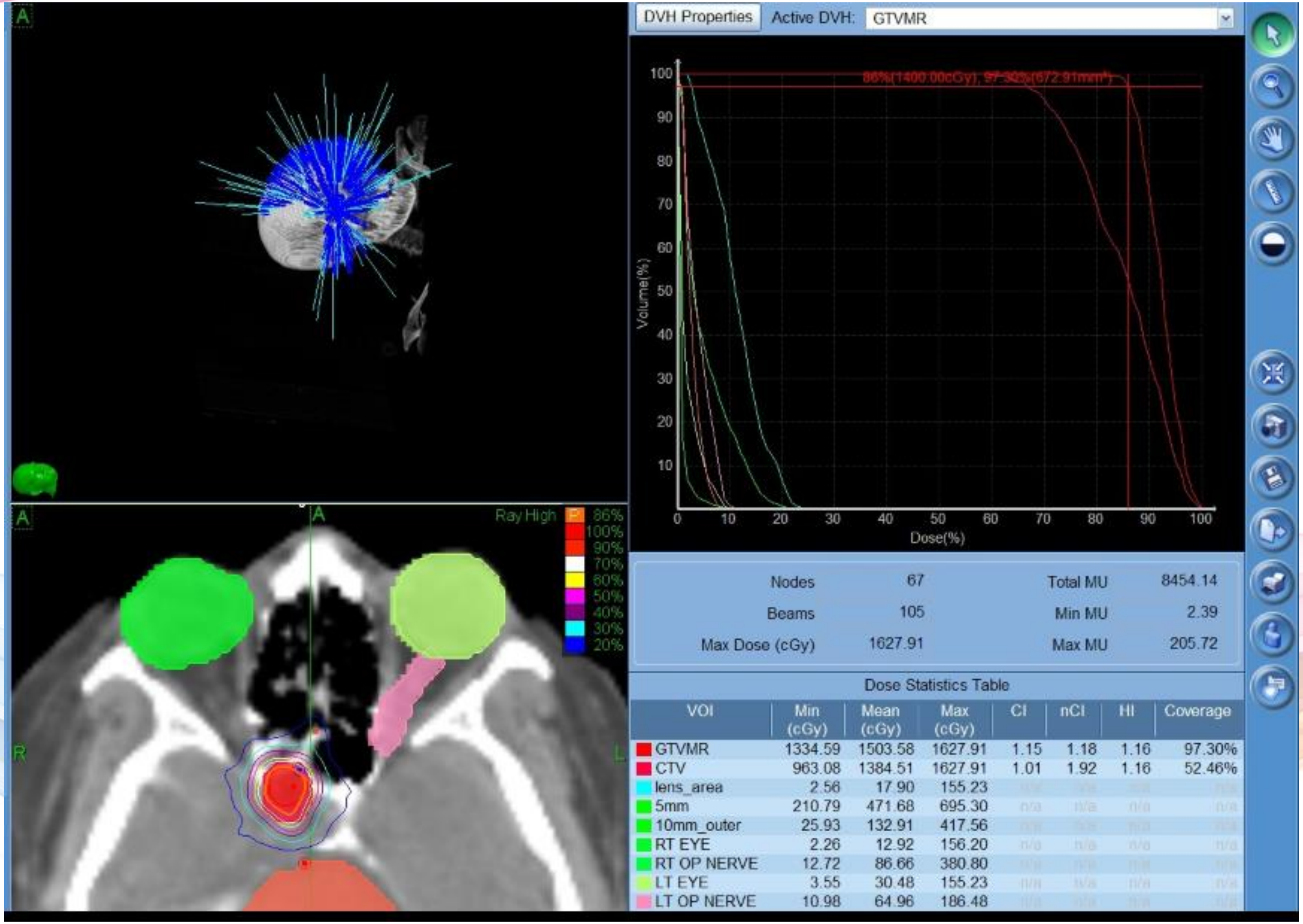


16.04.13	05.10.15



Pituitary adenoma post op residual 26yrs/F



Meningioma

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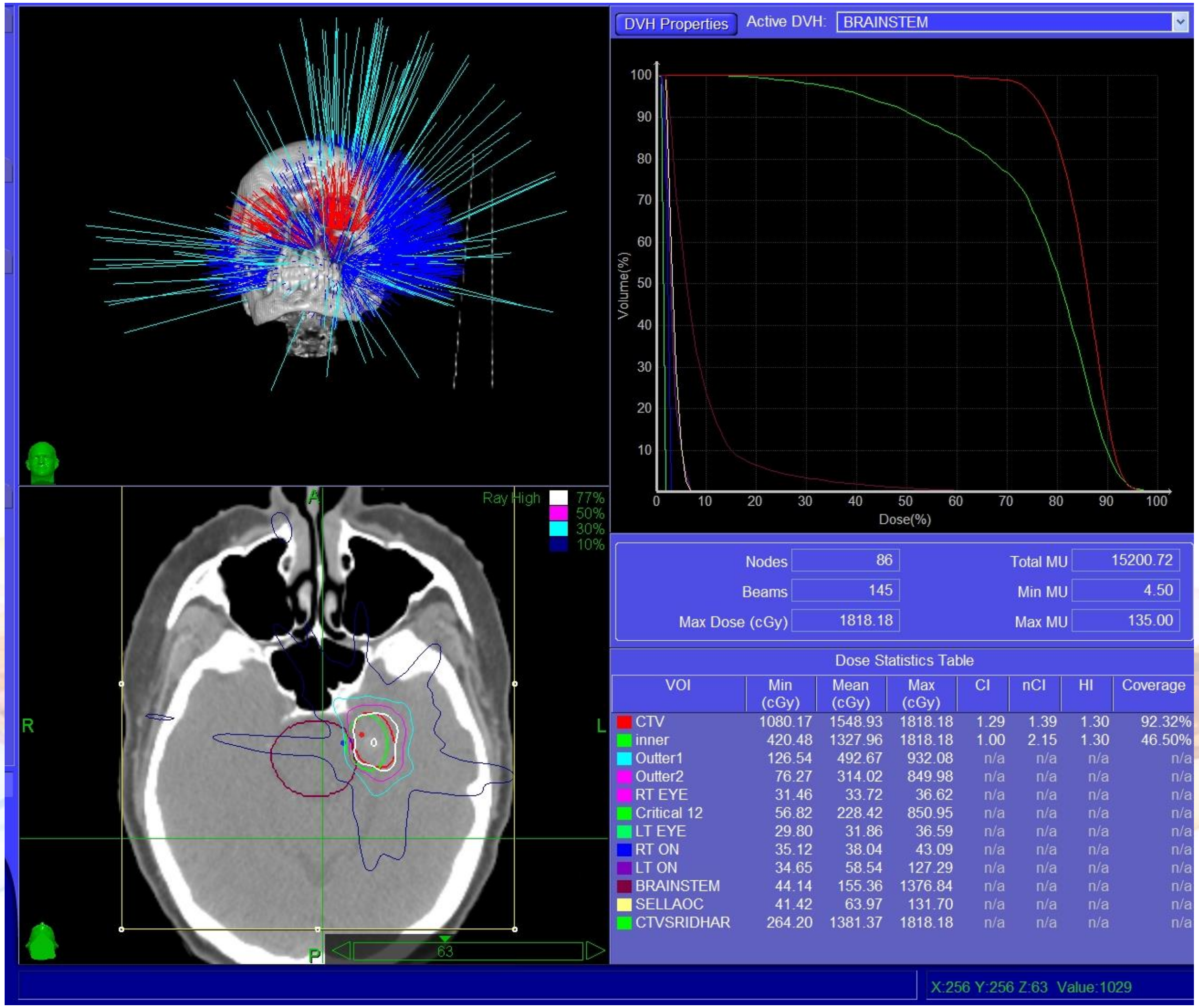
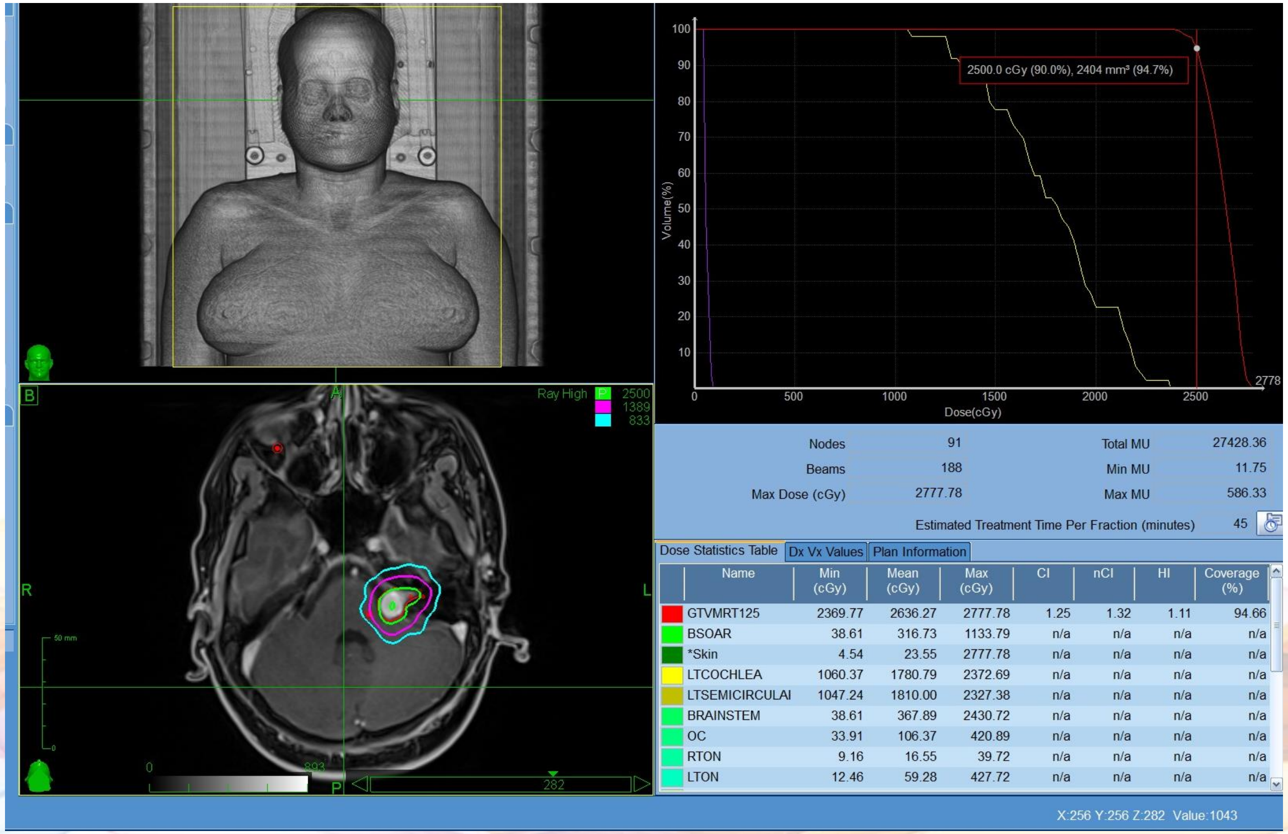
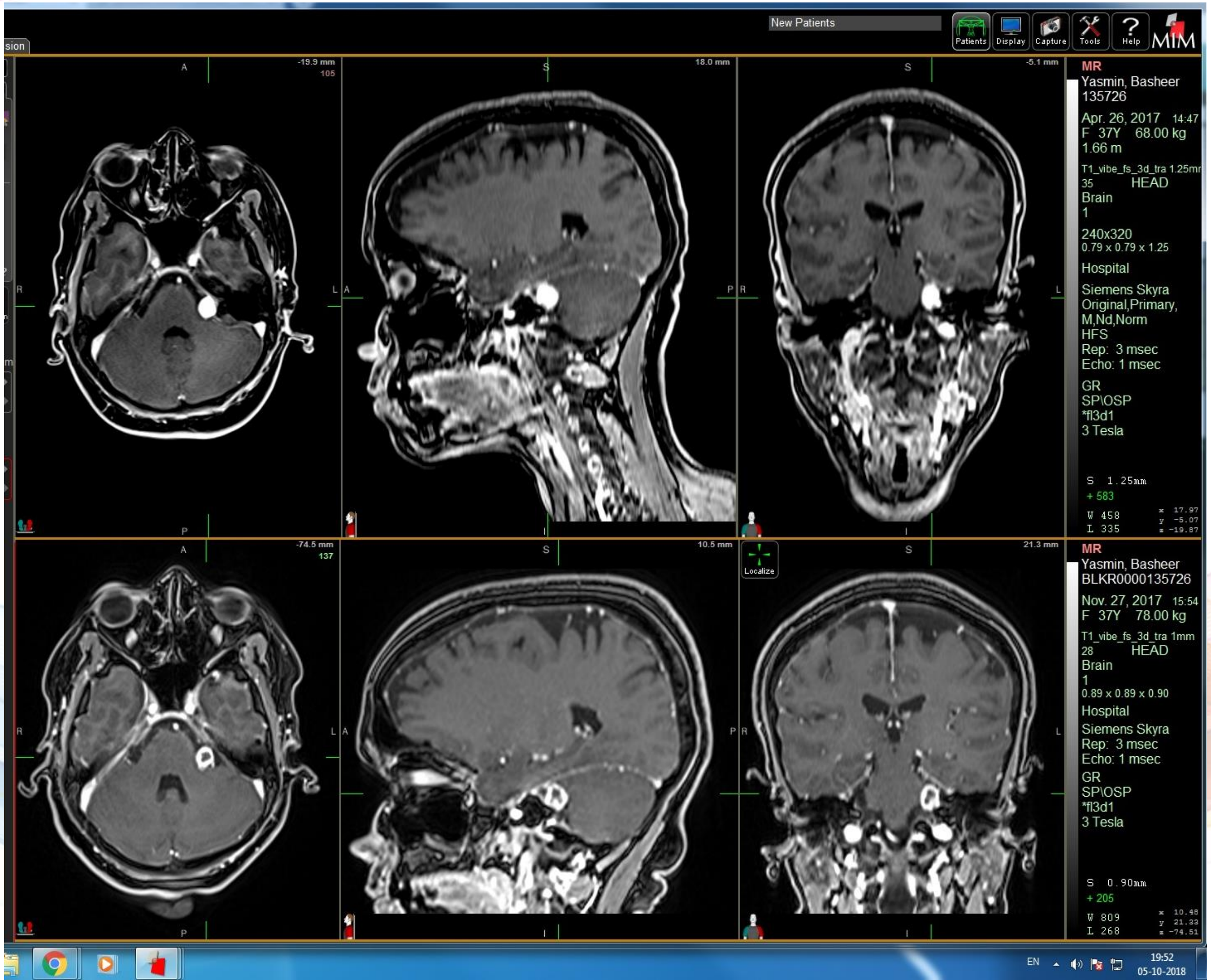
- N=146
- >4cm,Symptomatic-Surgery
- 12-14Gy/1#,18Gy/3#,25Gy/5#



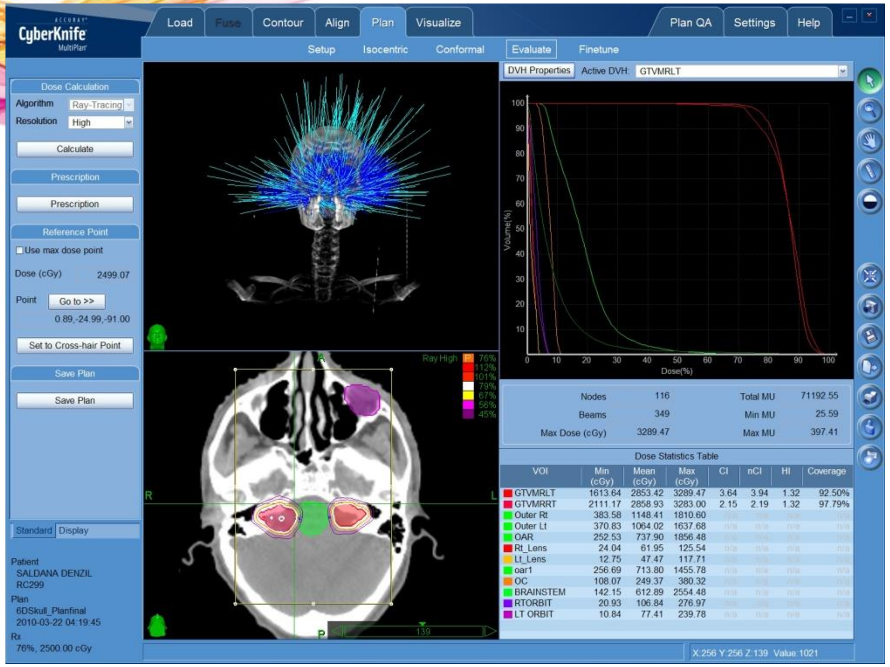
Acoustic Schwanoma

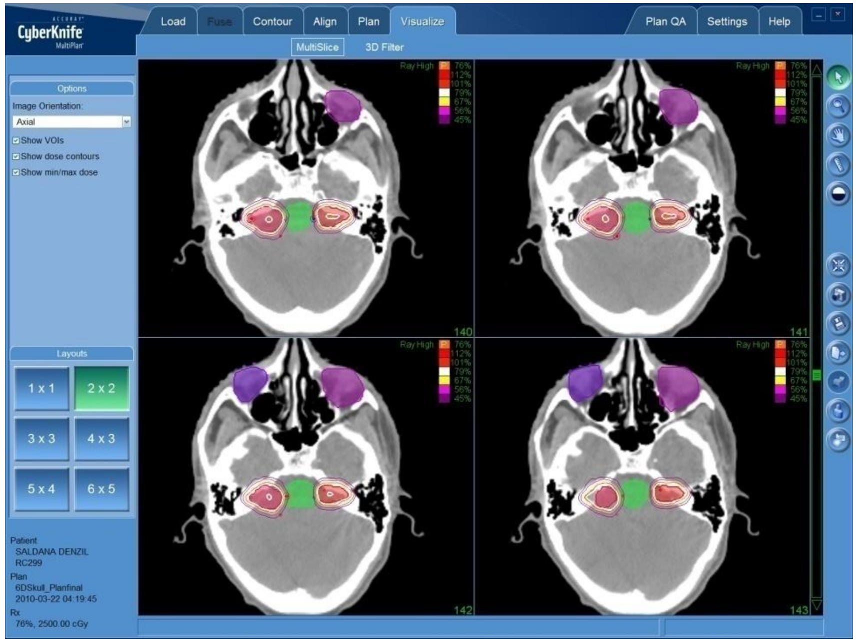
- N=128
- B/L=12
- Hearing/Brainstem
- 12-14Gy/1#,25Gy/5#

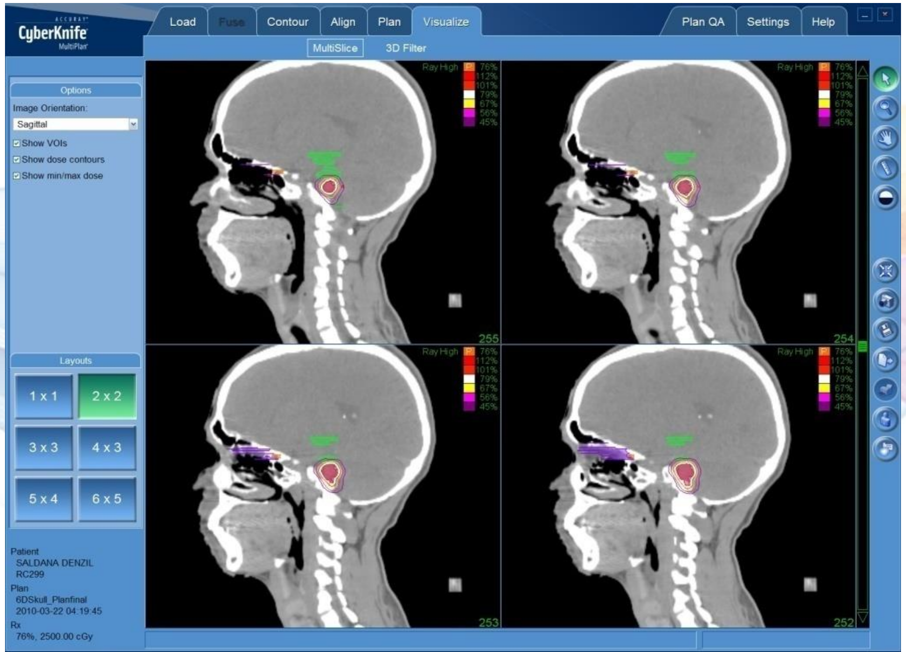


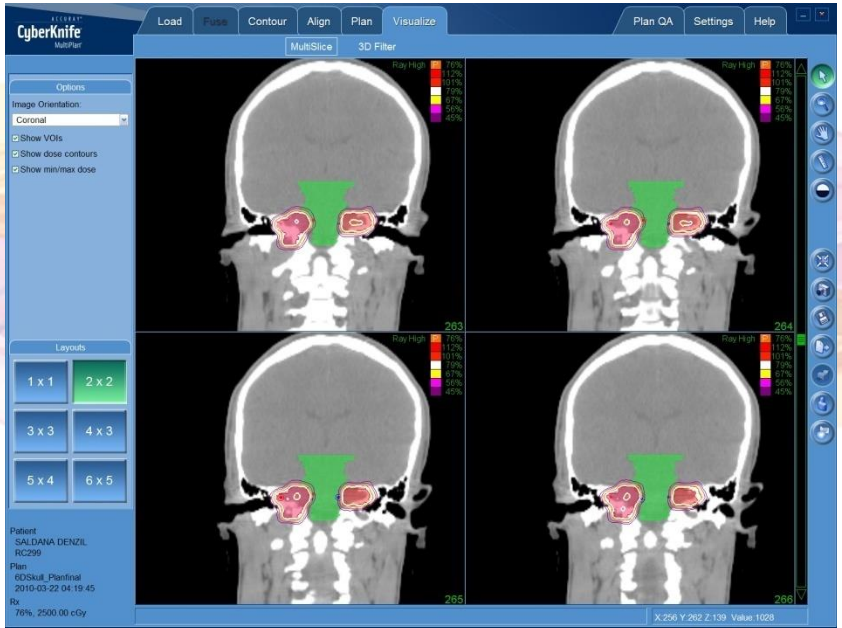

New Patients
Patients
Display
Capture
Tools
Help
MIM
MR
Yasmin, Basheer
135726
Apr. 26, 2017 14:47
F 37Y 68.00 kg
1.66 m
T1_vibe_fs_3d_tra 1.25mm
35 HEAD
Brain
1
240x320
0.79 x 0.79 x 1.25
Hospital
Siemens Skyra
Original,Primary,
M,Nd,Norm
HFS
Rep: 3 msec
Echo: 1 msec
GR
SP\OSP
*fl3d1
3 Tesla
S 1.25mm
+ 583
W 458
L 335
MR
Yasmin, Basheer
BLKR0000135726
Nov. 27, 2017 15:54
F 37Y 78.00 kg
T1_vibe_fs_3d_tra 1mm
28 HEAD
Brain
1
0.89 x 0.89 x 0.90
Hospital
Siemens Skyra
Rep: 3 msec
Echo: 1 msec
GR
SP\OSP
*fl3d1
3 Tesla
S 0.90mm
+ 205
W 809
L 268
Localize
19:52
05-10-2018

22yr/m/B/L Ac schwanoma

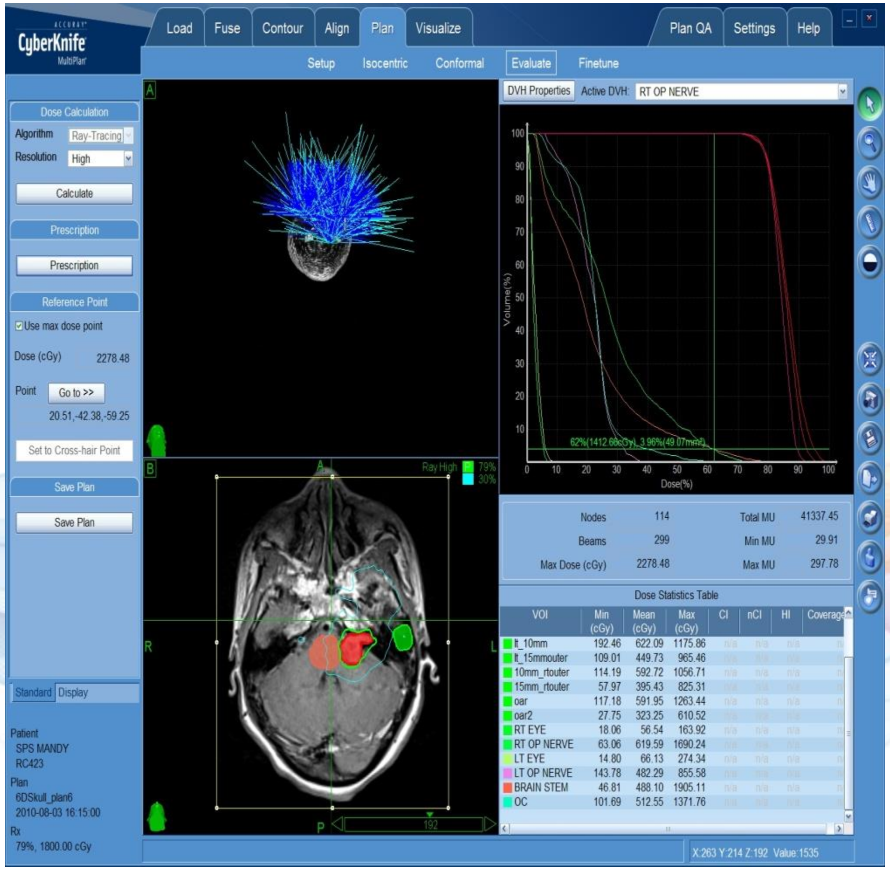








28yrs/F/NF1



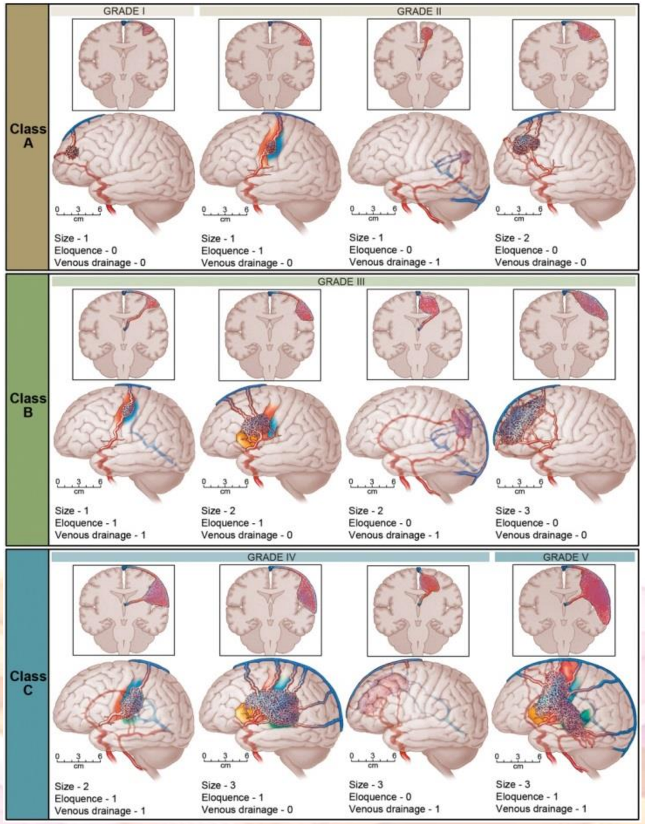
CyberKnife
MultiPlan
Load
Fuse
Contour
Align
Plan
Visualize
Plan QA
Settings
Help
Setup
Isocentric
Conformal
Evaluate
Finetune
Dose Calculation
Algorithm Ray-Tracing
Resolution High
Calculate
Prescription
Reference Point
Use max dose point
Dose (cGy) 2278.48
Point Go to >>
20.51,-42.38,-59.25
Set to Cross-hair Point
Save Plan
DVH Properties
Active DVH: RT OP NERVE
Volume(%)
Dose(%)
62%(1412.66cGy), 3.96%(49.07mm3)
Nodes 114
Beams 299
Max Dose (cGy) 2278.48
Total MU 41337.45
Min MU 29.91
Max MU 297.78
Dose Statistics Table
VOI | Min (cGy) | Mean (cGy) | Max (cGy) | CI | nCI | HI | Coverage
lt_10mm 192.46 622.09 1175.86
lt_15mmouter 109.01 449.73 965.46
10mm_rtouter 114.19 592.72 1056.71
15mm_rtouter 57.97 395.43 825.31
oar 117.18 591.95 1263.44
oar2 27.75 323.25 610.52
RT EYE 18.06 56.54 163.92
RT OP NERVE 63.06 619.59 1690.24
LT EYE 14.80 66.13 274.34
LT OP NERVE 143.78 482.29 855.58
BRAIN STEM 46.81 488.10 1905.11
OC 101.69 512.55 1371.76
Patient
SPS MANDY
RC423
Plan
6DSkull_plan6
2010-08-03 16:15:00
Rx
79%, 1800.00 cGy
X:263 Y:214 Z:192 Value:1535

CyberKnife
MultiPlan
Load
Fuse
Contour
Align
Plan
Visualize
Plan QA
Settings
Help
Setup
Isocentric
Conformal
Evaluate
Finetune
Density Model
HCG-GE CT scan
Density Overrides
Contour Correction
Beam Intersection
Allow Beam Intersection
lt_10mm
lt_15mmouter
10mm_rtouter
15mm_rtouter
oar
oar2
RT EYE
RT OP NERVE
LT EYE
LT OP NERVE
BRAIN STEM
OC
Patient
SPS MANDY
RC423
Plan
6DSkull_plan6
2010-08-03 16:15:00
Rx
79%, 1800.00 cGy
X:234 Y:198 Z:202 Value:1371

SPETZLER-MARTIN AVM Grading System

HCG-AVM

- N=26
- DSA
- Plain CT,CT angio
- MRI,MRA,FMRI
- Bleeding-6 weeks
- Size,location
- SRS 1 fraction 14-18Gy
- FSRS 3-5 18-25Gy



Study	No.	Size/volume	Total dose/ fractions	Prior treatment	Follow-up time	Obliteration rate	Complication
Aoyama, 2001[4]	HSRT: 26	Eloquent area or >2.5 cm, mean: 2.26 cm	24–28.8 Gy/4 (mean: 26.8 Gy)	Embolization: 11% Surgery: 9%	>1 year (mean: 35.4 months)	At 3 years: 53%	Hemorrhage: 12% Radiation necrosis: 0%
	SRS: 27	Non-eloquent area or <2.5 cm, mean: 1.78 cm	12–20 Gy (mean: 18.5 Gy)		>1 year (mean: 34.6 months)	At 3 years: 71%	Hemorrhage: 7% Radiation necrosis: 8%
Lindvall, 2003[23]	HSRT: 29	Mean: 11.5 mL	30–35 Gy/5 (median: 32.6 Gy)	Embolization: 38% Surgery: 17%	8 years (mean: 38 months)	At 2 years: 56% (4–10 mL) 50% (>10 mL) At 5 years: 81% (4–10 mL) 70% (>10 mL)	Hemorrhage: 7% Epilepsy: 7% Radiation necrosis: 7%
Veznedaroglu, 2004[35]	HSRT: 24	Mean: 23.8 mL	42 Gy/6 (6 patients)	Embolization: 86%	>5 years (mean: 102 months)	83% (at mean latency 108 ± 52 weeks)	14% (86% with radiographic change)
		Mean: 14.5 mL	30 Gy/6 (18 patients)	Embolization: 57%	>5 years (mean: 82 months	22% (at mean latency 192 weeks)	8.7% (30% with radiographic change)
Chang*, 2004[8]	HSRT: 33	Eloquent area or >2.5 cm	20–28 Gy/4 (mean: 25.9 Gy)	Embolization: 10% Surgery: 15%	Mean: 52 months	At 3 years: 32% At 5 years: 61% At 6 years: 71%	Hemorrhage: 22%/5 years Radiation necrosis: 3%
	SRS: 42	Non-eloquent area or <2.5 cm	12–20 Gy (mean: 19.3 Gy)			At 3 years: 52% At 5 years: 81% At 6 years: 81%	Hemorrhage: 8%/5 years Radiation necrosis: 10% Epilepsy: 2%
Zabel-du Bois, 2006[41]	HSRT: 15	> 4cm Median: 27 mL	20–32.5 Gy/4–5 (median: 26 Gy)	Embolization: 27% Surgery: 0%	Median: 2.6 years	At 3 years: 17% At 4 years: 33%	Hemorrhage: 20% Radiation necrosis: 0%
	SRS: 33	Median: 7 mL	15–19 Gy (median: 17 Gy)	Embolization: 24% Surgery: 3%		At 3 years: 47% At 4 years: 60%	Hemorrhage: 21% Radiation necrosis: 0%
Xiao, 2010[37]	HSRT: 20	>5 cm, median: 46.84 mL	25–30 Gy/5–6 (median: 30 Gy)	Embolization: 50%	Median: 32 months	0% Median post-treatment volume: 13.51 mL	Increase seizure: 5% Ischemic stroke: 5% Hemorrhage: 2.06%/year

*Continuum of the Aoyama *et al.* study, HSRT: Hypofractionated stereotactic radiotherapy

Study	No.	Size/volume	Total dose/ fractions	Prior treatment	Follow-up time	Obliteration rate	Complication
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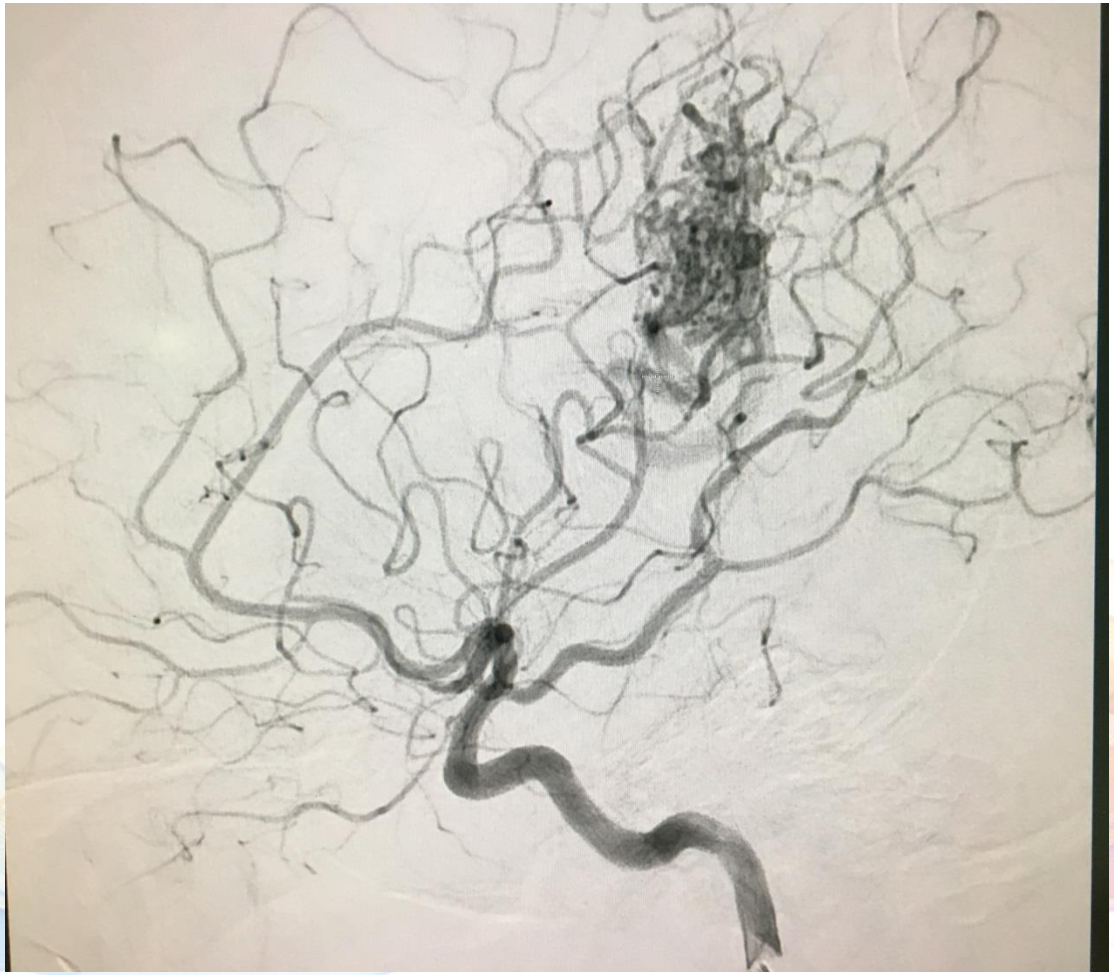
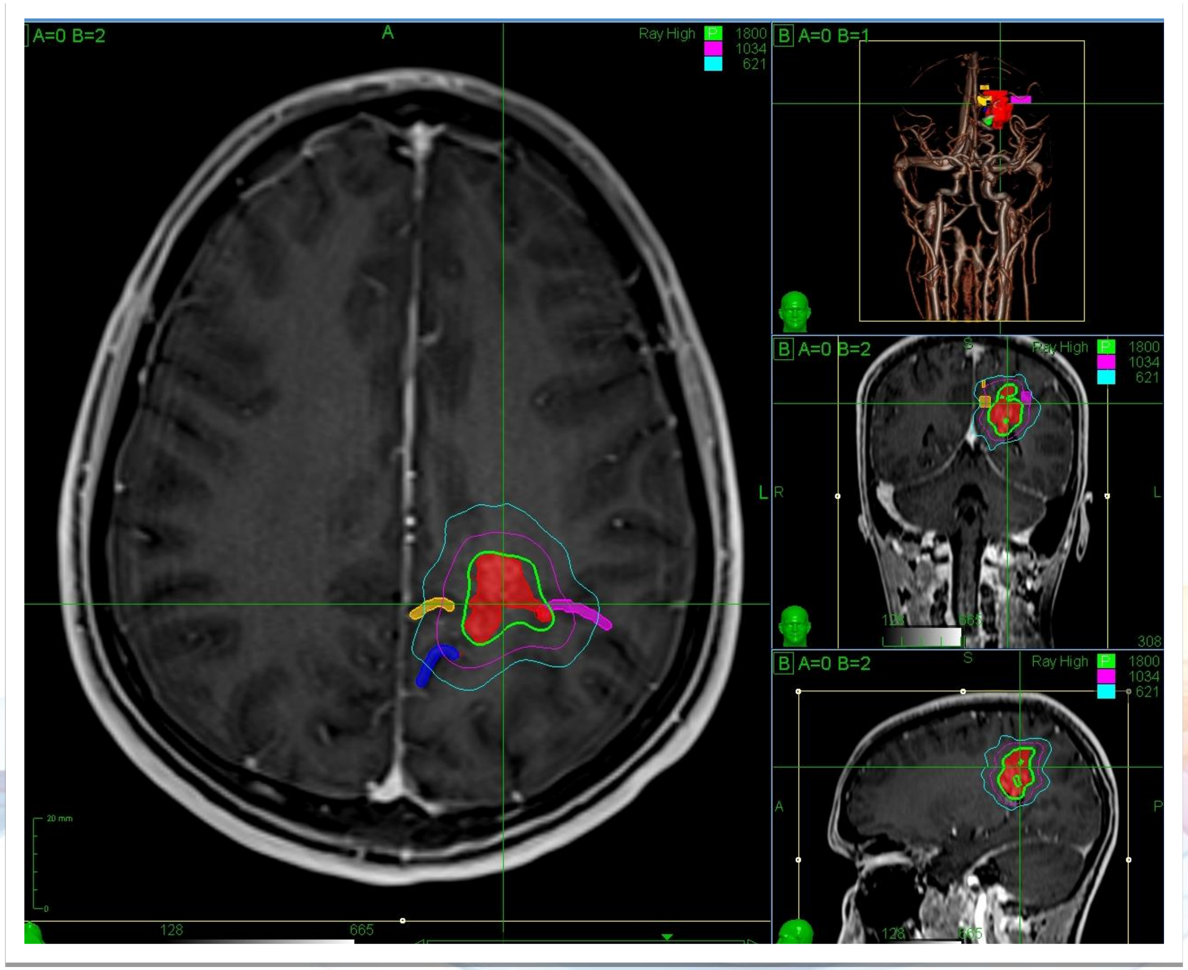
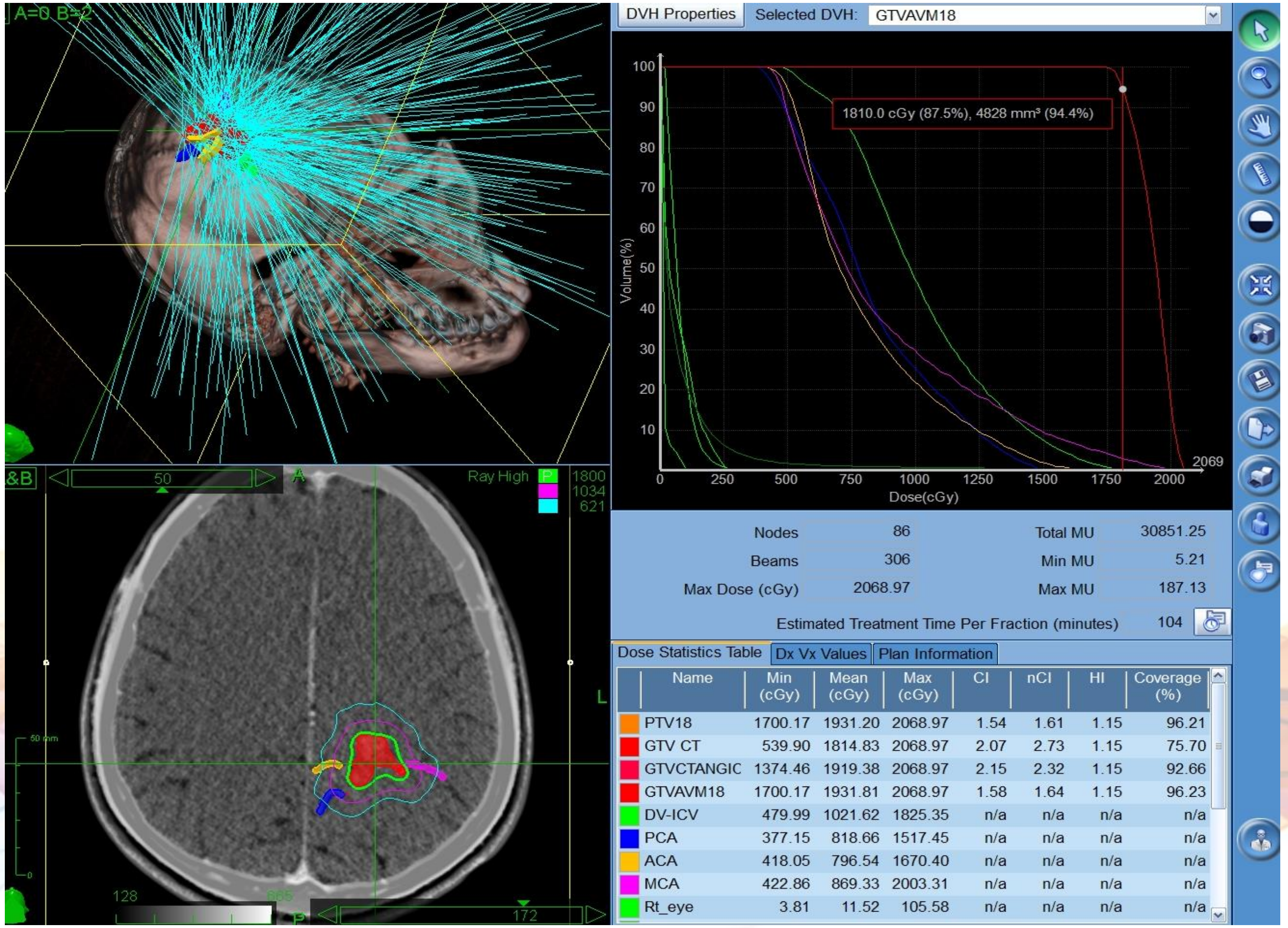
*Continuum of the Aoyama *et al.* study, HSRT: Hypofractionated stereotactic radiotherapy

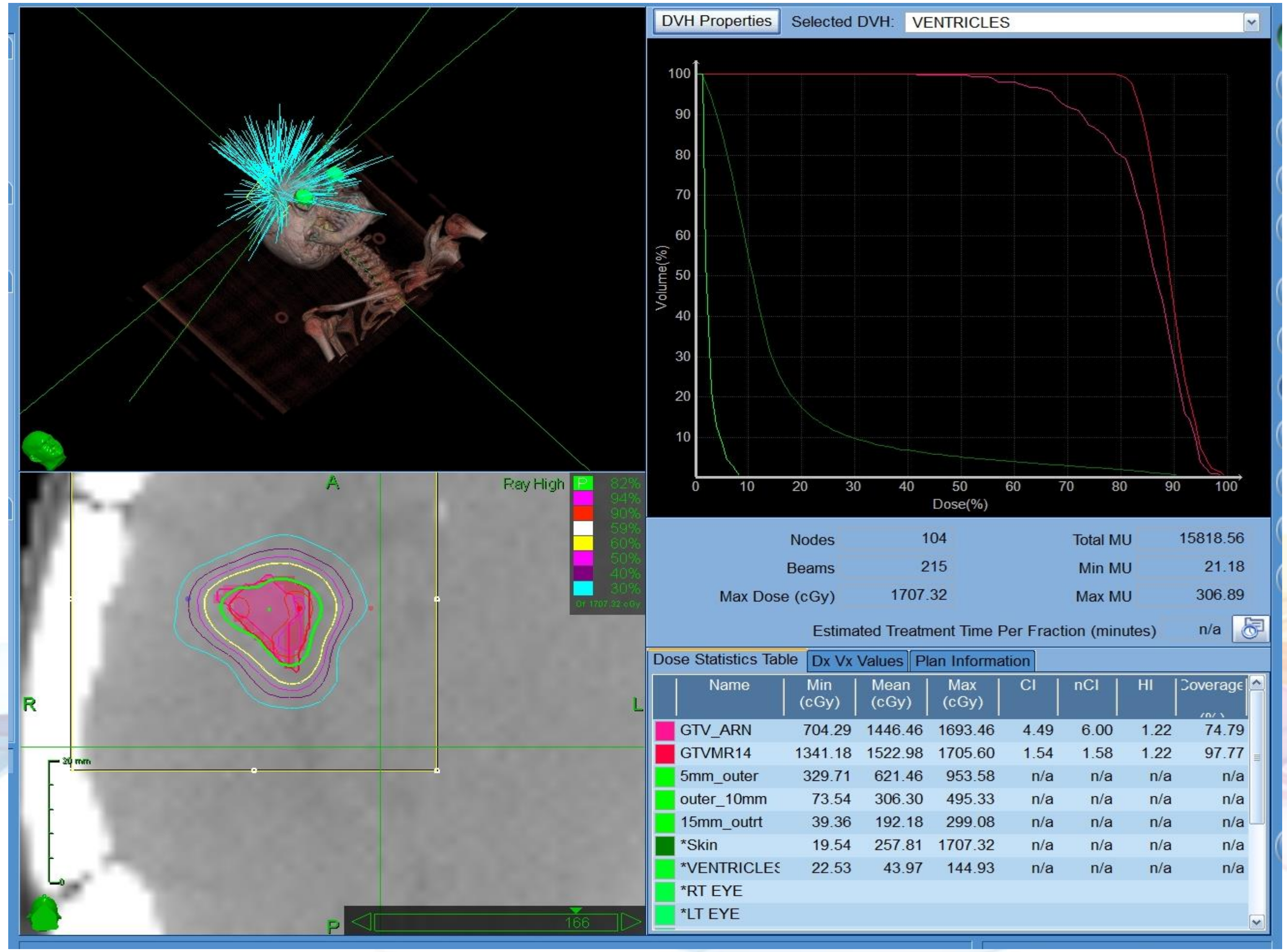
Case 1.16yrs/M/ICT

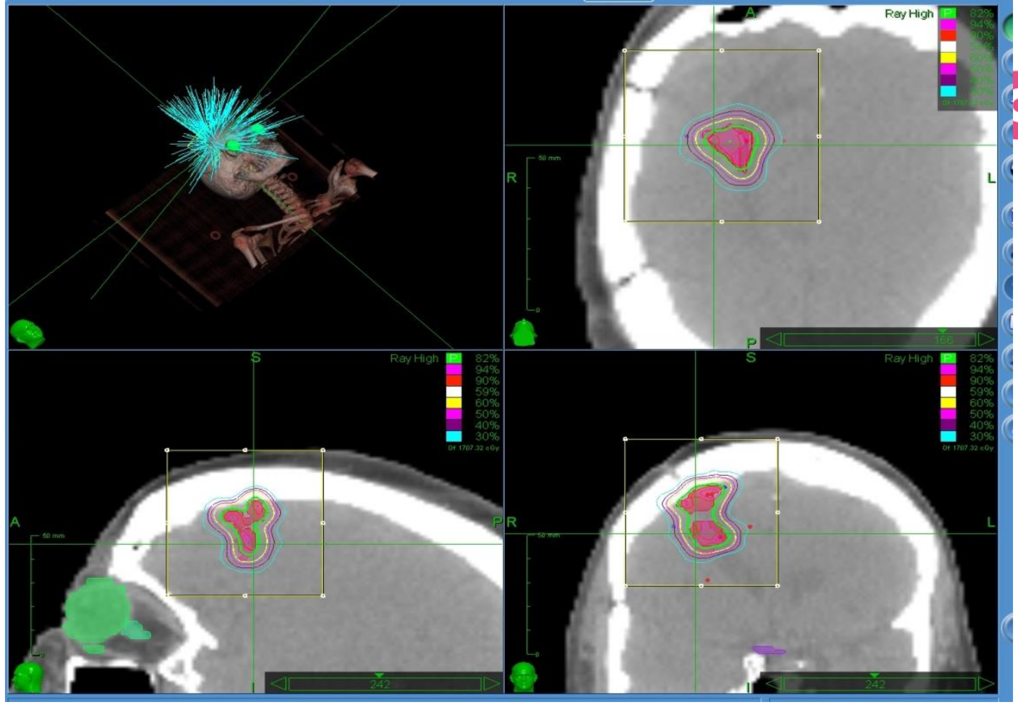


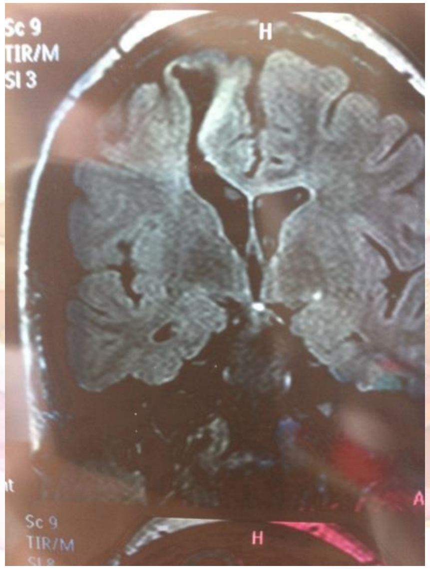

A=0 B=2
Ray High
1800
1034
621
B A=0 B=1
B A=0 B=2
B A=0 B=2

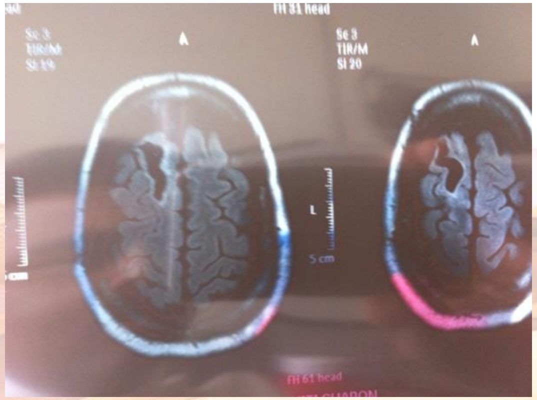

DVH Properties
Selected DVH: GTVAVM18
1810.0 cGy (87.5%), 4828 mm³ (94.4%)
Volume(%)
Dose(cGy)
Ray High
1800
1034
621
Nodes 86
Beams 306
Max Dose (cGy) 2068.97
Total MU 30851.25
Min MU 5.21
Max MU 187.13
Estimated Treatment Time Per Fraction (minutes) 104
Dose Statistics Table
Dx Vx Values
Plan Information
Name | Min (cGy) | Mean (cGy) | Max (cGy) | CI | nCI | HI | Coverage (%)
PTV18 1700.17 1931.20 2068.97 1.54 1.61 1.15 96.21
GTV CT 539.90 1814.83 2068.97 2.07 2.73 1.15 75.70
GTVCTANGIC 1374.46 1919.38 2068.97 2.15 2.32 1.15 92.66
GTVAVM18 1700.17 1931.81 2068.97 1.58 1.64 1.15 96.23
DV-ICV 479.99 1021.62 1825.35 n/a n/a n/a n/a
PCA 377.15 818.66 1517.45 n/a n/a n/a n/a
ACA 418.05 796.54 1670.40 n/a n/a n/a n/a
MCA 422.86 869.33 2003.31 n/a n/a n/a n/a
Rt_eye 3.81 11.52 105.58 n/a n/a n/a n/a

Case 2.30yrs/F

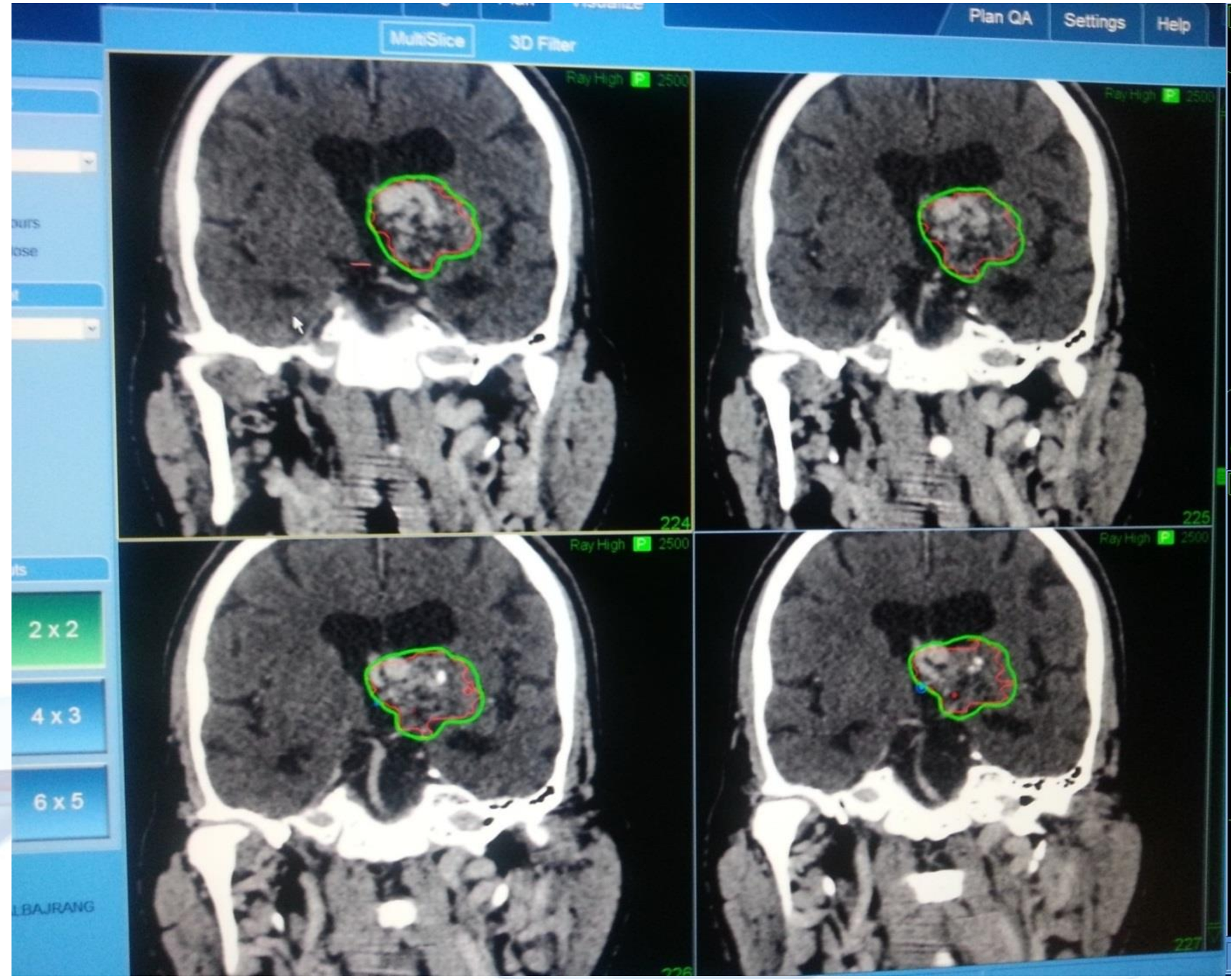


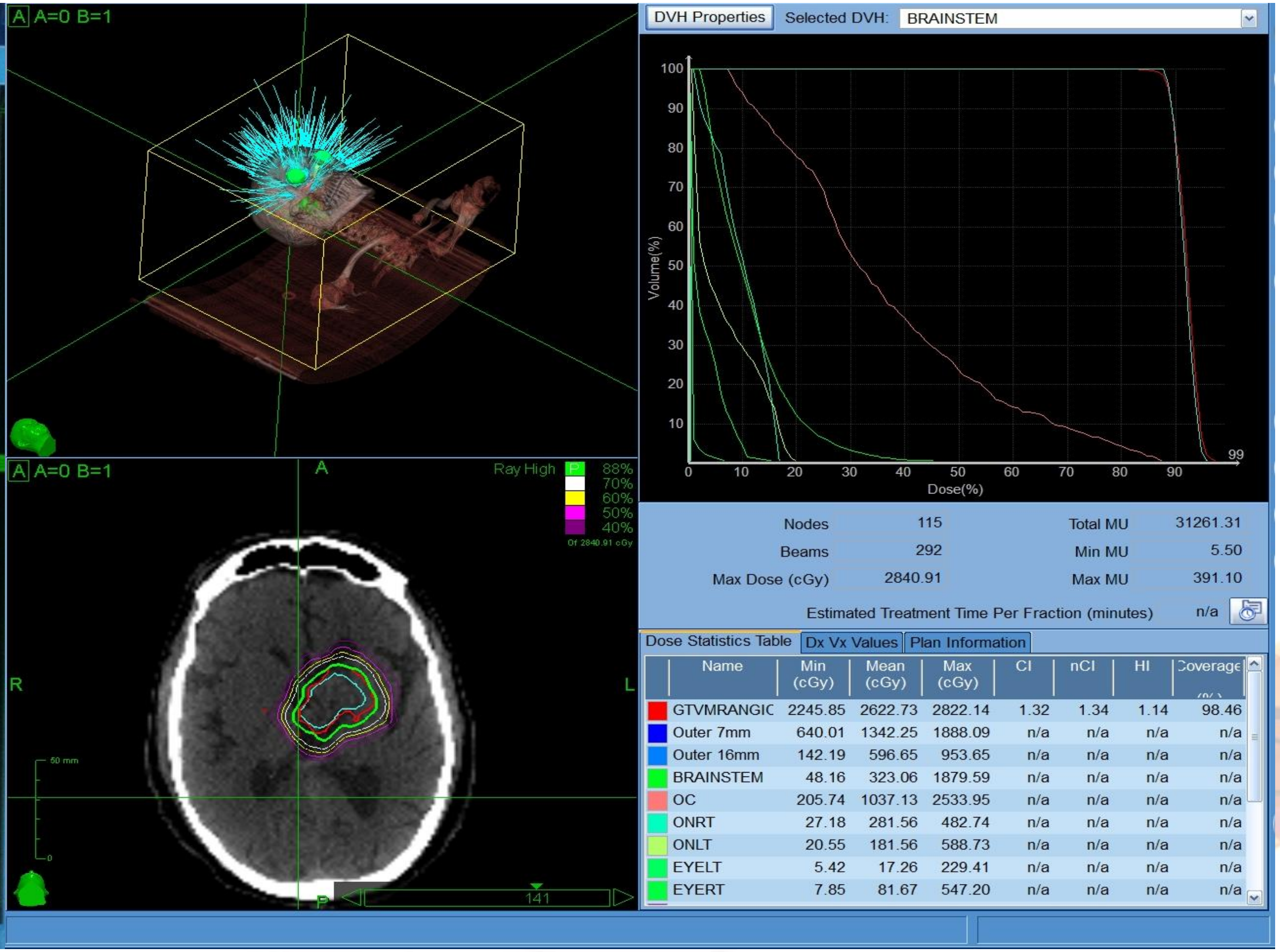






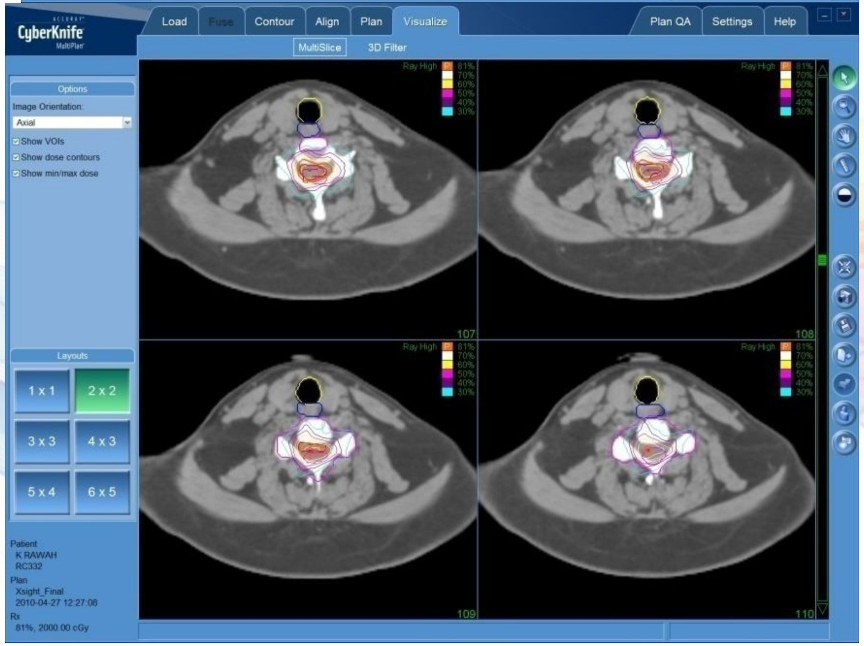
Case 4.60yr/m/Thalamic AVM

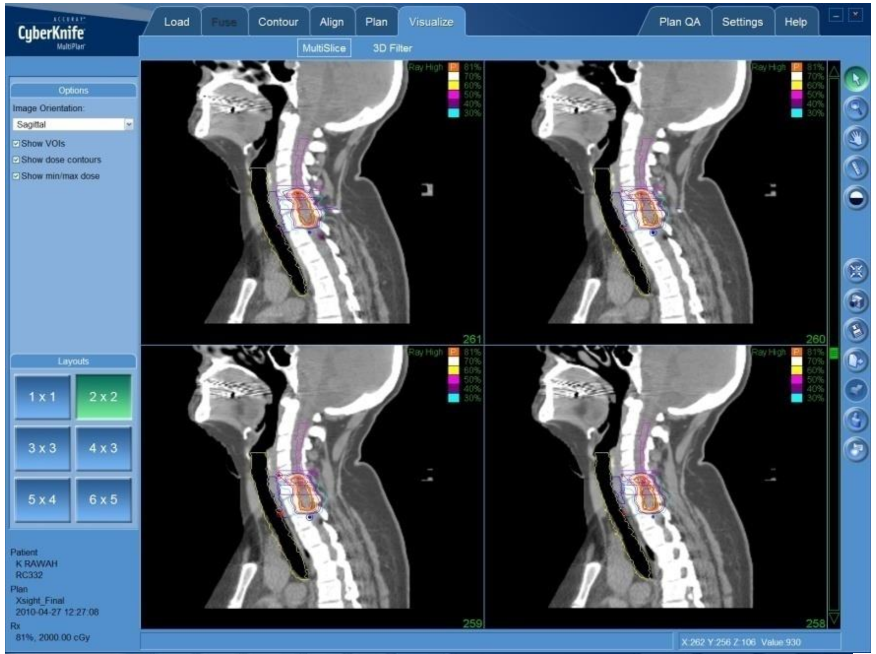


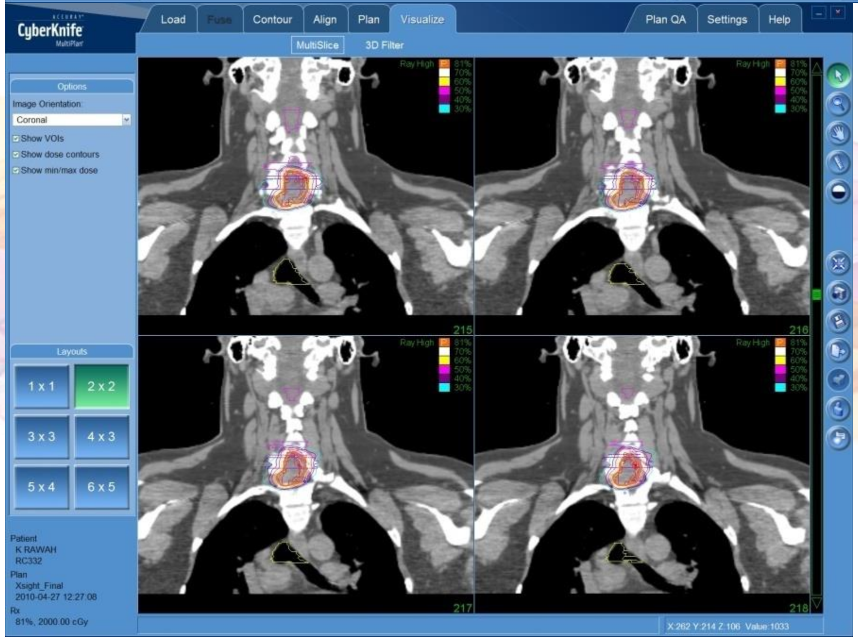


Case 8.32yr/F/Spinal AVM

HCG Hospitals
adding life to years

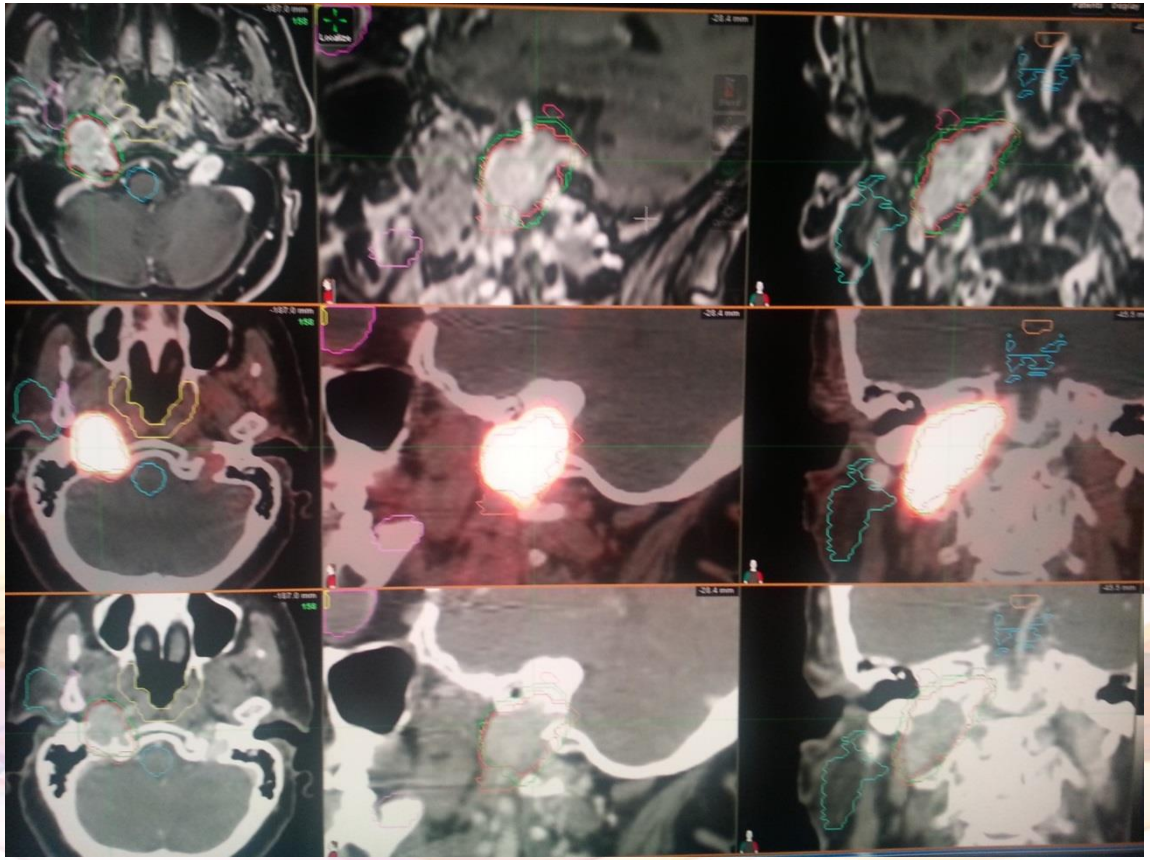






Glomus jugular tumour

- N=26
- 25Gy/5#
- Symptomatic- Sandostatin LAR



Novel treatment (new drug/intervention; established drug/procedure in new situation)

HCG Hospitals
adding life to years

CASE REPORT

Robotic-arm stereotactic radiosurgery as a definitive treatment for gelastic epilepsy associated with hypothalamic hamartoma

Sridhar Papaiah Susheela,[1] Swaroop Revannasiddaiah,[2] Govindarajan J Mallarajapatna,[3] Ajaikumar Basavalingaiah[1]

[1]Department of Radiation Oncology, HealthCare Global-Bangalore Institute of Oncology, Bengaluru, Karnataka, India
[2]Department of Radiation Oncology, Swami Rama Cancer Hospital & Research Institute, Haldwani, Uttarakhand, India
[3]Department of Radiology & Imaging, HealthCare Global-Bangalore Institute of Oncology, Bengaluru, Karnataka, India

Correspondence to
Dr Swaroop Revannasiddaiah, swarooptheone@gmail.com

SUMMARY

Gelastic seizures, characterised by paroxysms of pathological laughter, are most often associated with an underlying hypothalamic hamartoma. This report describes the definitive treatment using stereotactic-radiosurgery for a teenaged child whose gelastic epilepsy was found refractory to various antiepileptic drugs. Since surgery was not consented to, the child was referred to us for stereotactic radiosurgery (SRS), which was delivered with robotic-arm -SRS to a dose of 30 Gy in five fractions in five consecutive days. A decrease in the frequency of seizures was noticeable as early as within a week, and at 12 months after the procedure, there has been a total cessation of seizures.

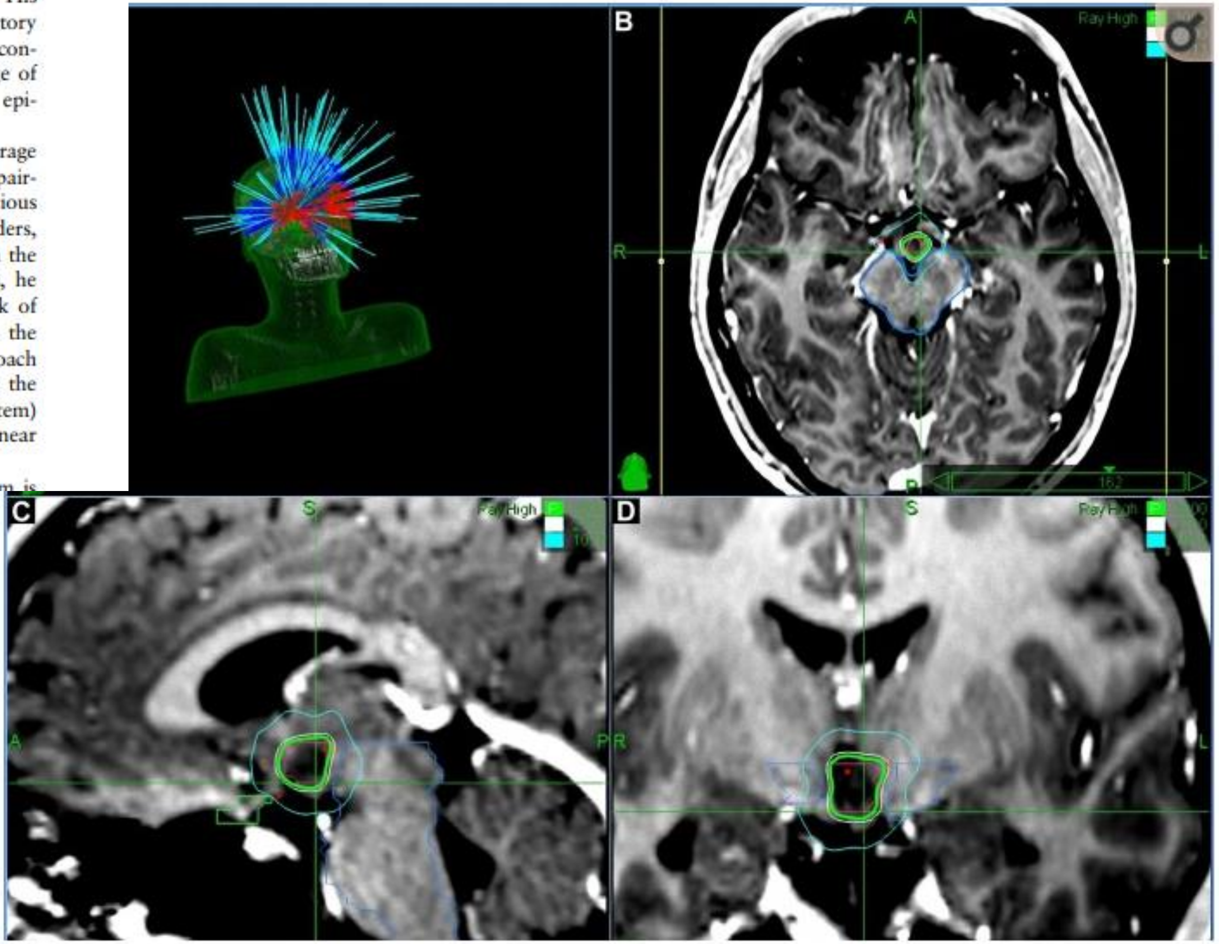
BACKGROUND

Hypothalamic hamartoma associated gelastic epilepsy characterised by episodes of ictal-laughter warrant timely treatment as they are known to pro-

in maintaining freedom from gelastic seizures. His symptoms subsequently became totally refractory to AED. However, his symptoms were initially confined to 'laughing fits', after he attained the age of 12 years, he began experiencing occasional episodes of generalised seizures too.

He was of normal intelligence with an average performance at school, with no cognitive impairments. There were no histories of precocious puberty, eating disorders, behavioural disorders, trauma or metabolic disorders. However, given the ineffectiveness of AEDs in preventing seizures, he was offered definitive treatment, given the risk of progression to epileptic encephalopathy. Since the patient desired to undergo a non-surgical approach for treatment, he was offered SRS with either the *GammaKnife* (SRS using a cobalt-60-based system) or the *CyberKnife* (radiosurgery using a linear accelerator mounted upon a robotic arm).

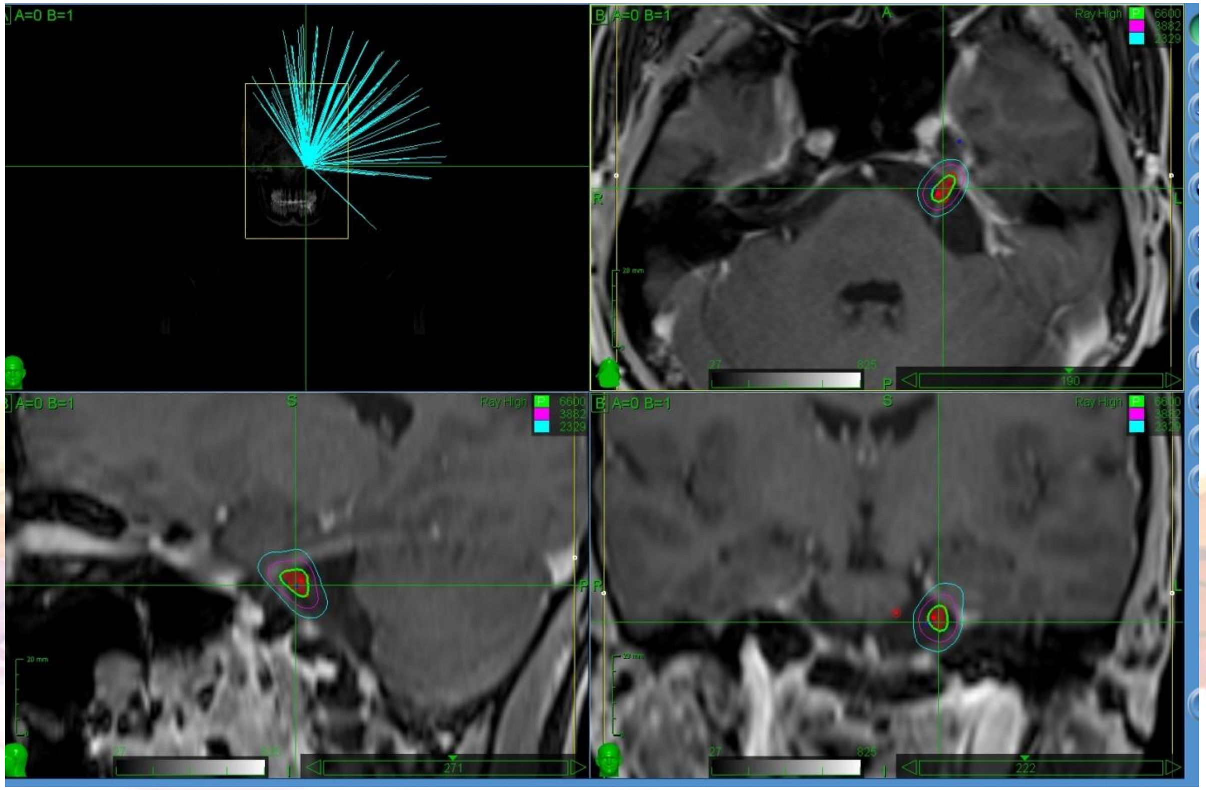
Despite the fact that the *GammaKnife* system is



FUNCTIONAL

Trigeminal neuralgia

- N=27
- 56Gy-60Gy,Max 76-80Gy



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adding life to years

Radiotherapy & Oncology
European Society of Radiotherapy and Oncology

May 2017 Volume 123, Supplement 1, Page S608

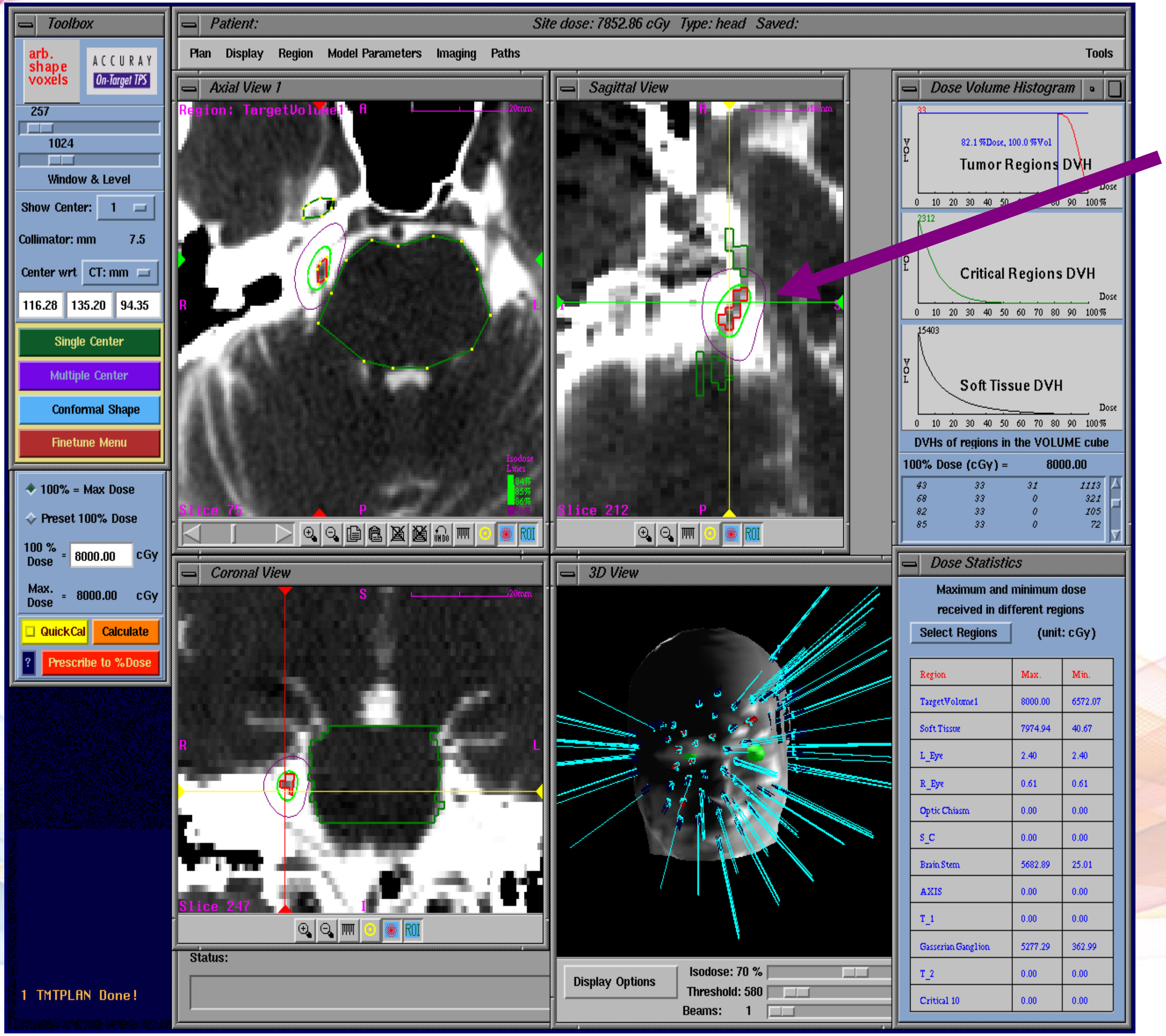
EP-1111: Cyber knife for Idiopathic Trigeminal Neuralgia - Novel technique to reduce brainstem dose

P.S. Sridhar, N. Madhusudhan, K. Roopesh, H. Madhusudhan, R. Satish, G. Swaroop, A. Jerrin, A. Pichandi, J. Vijaykumar, M. Praveen kumar, S. Shivkumar, M. Arunakumari, G. Monica, B. Ramesh, K. Gurunath, B. Ajai kumar

Open Access
DOI: https://doi.org/10.1016/S0167-8140(17)31547-5

⊞ Article Info

SRS for Trigeminal Neuralgia



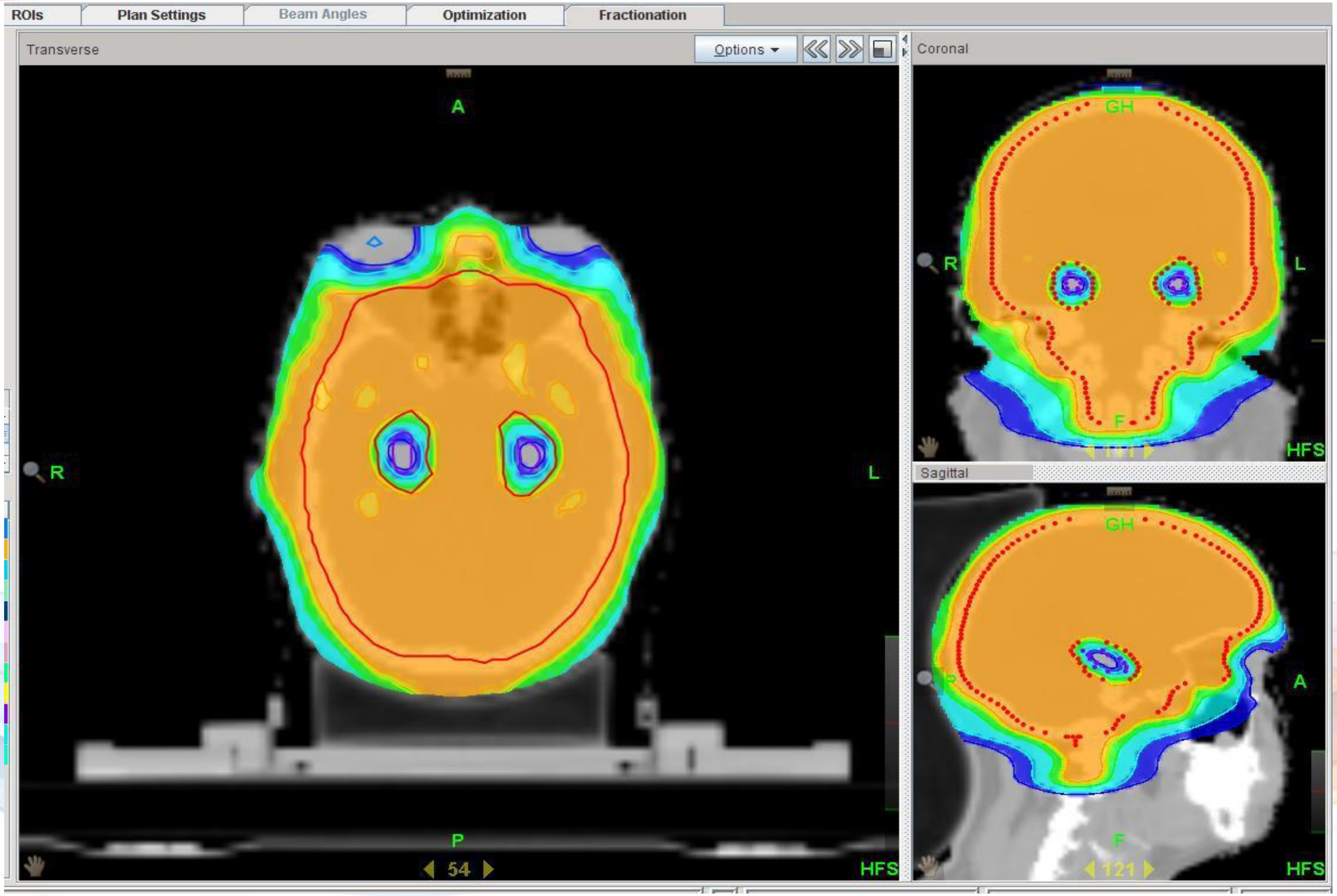
Measure length!!


2

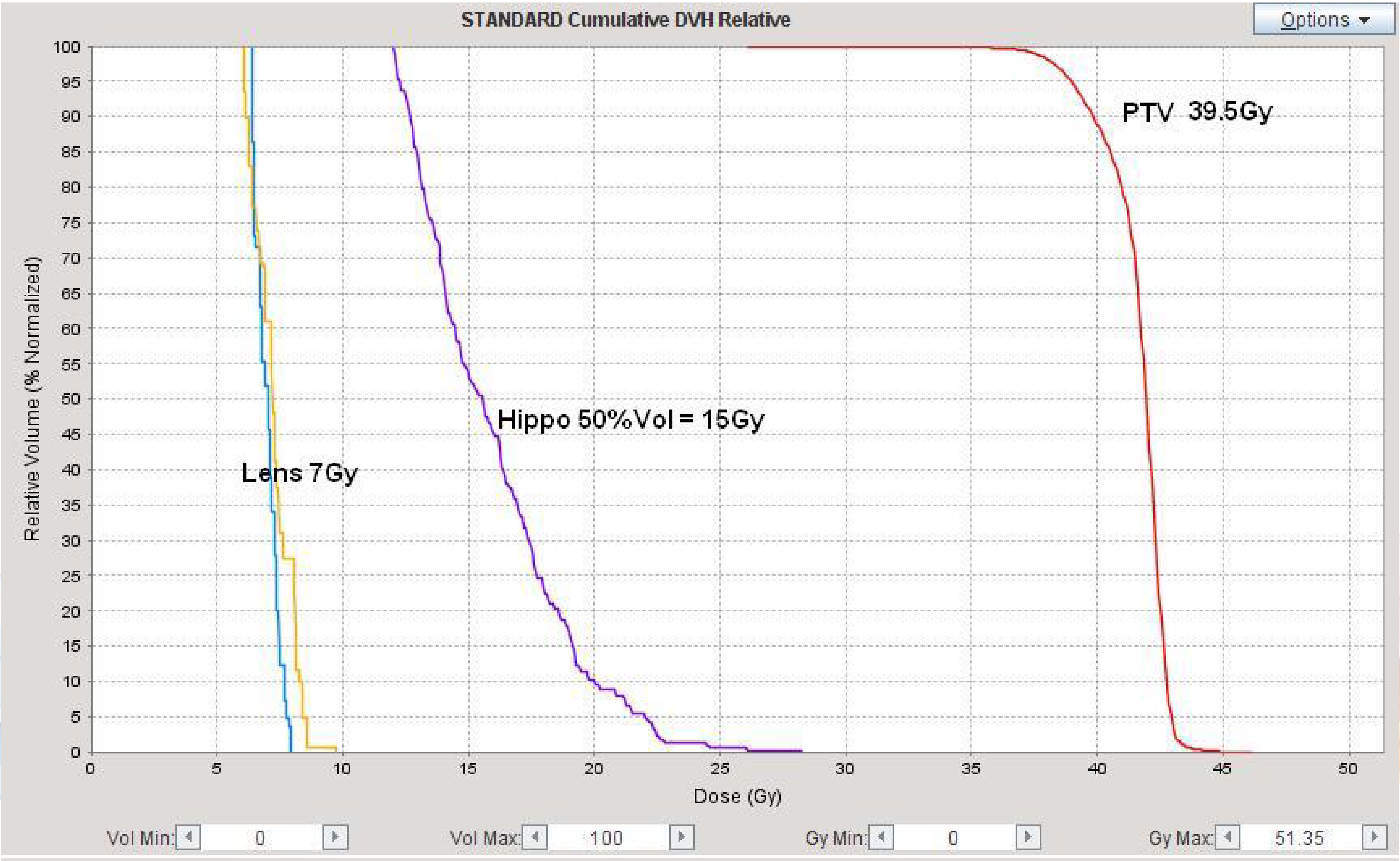
Brain Mets

WBRT-30Gy/10Fr,SIB 45Gy/10
Hippocampal sparing
SRS – 14-21Gy
24Gy-35Gy/3-5Fr
12-20Gy/1-2Fr boost/reirradiation
PET CT
MRI
Neurocognitive tests

WBRT…


ROIs
Plan Settings
Beam Angles
Optimization
Fractionation
Transverse
Options
A
R
L
P
54
HFS
Coronal
GH
R
L
F
HFS
Sagittal
GH
A
T
F
121
HFS

WBRT..

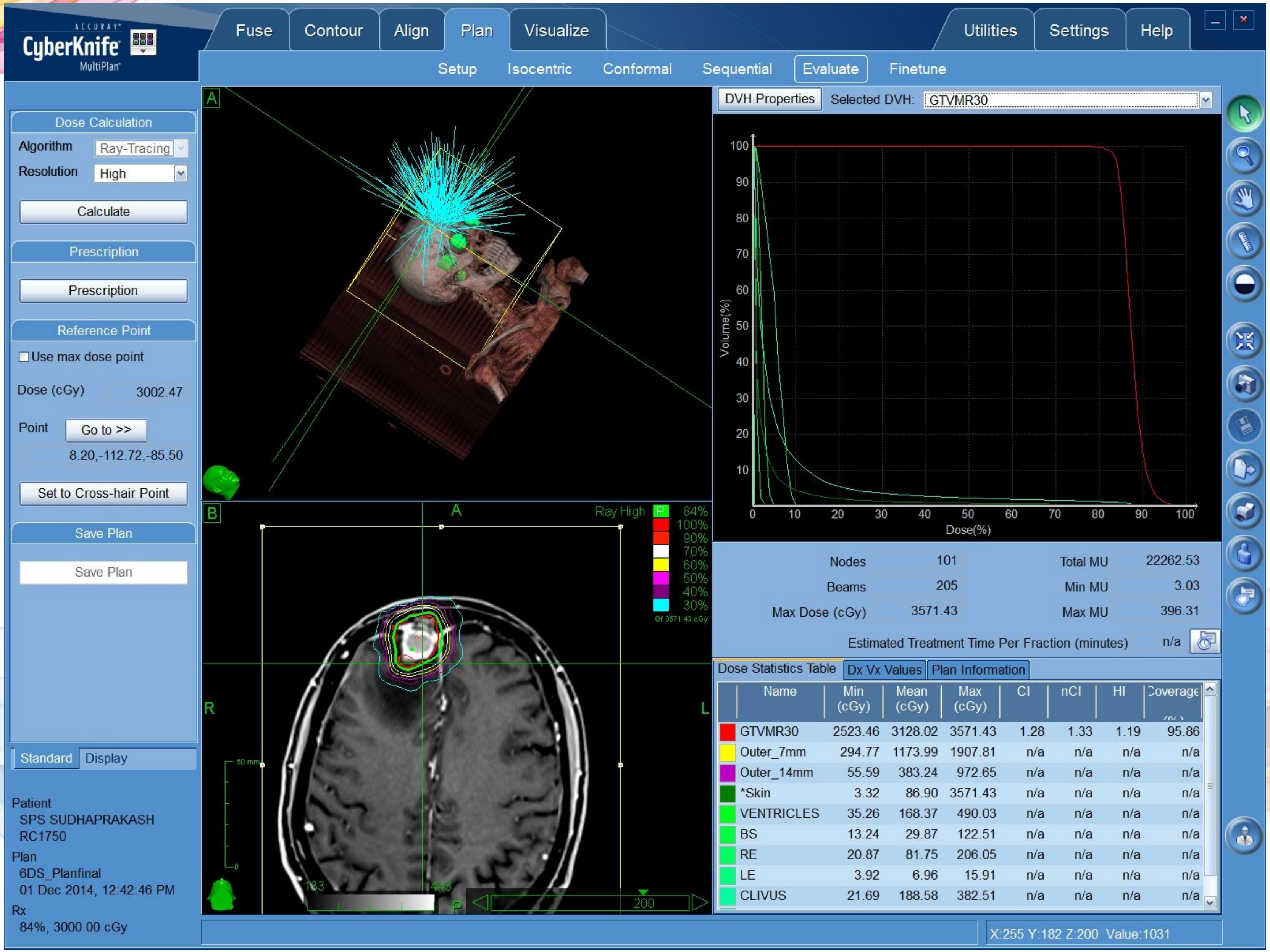


STANDARD Cumulative DVH Relative
Options
Relative Volume (% Normalized)
Dose (Gy)
PTV 39.5Gy
Hippo 50%Vol = 15Gy
Lens 7Gy
Vol Min: 0
Vol Max: 100
Gy Min: 0
Gy Max: 51.35

Case 1.69Yrs/F/Ca Lung with Multiple Brain mets

Case 2.62yrs/F/ca breast with brain mets

Hospitals
adding life to years



GLIOMA

How we do-post MSR

- History/Clinical/Neurocognitive
- Biopsy/IHC/Genomics
- DOPA PET CT/RT Planning
- MRI/MRS/Functional brain
- MDT
- FU

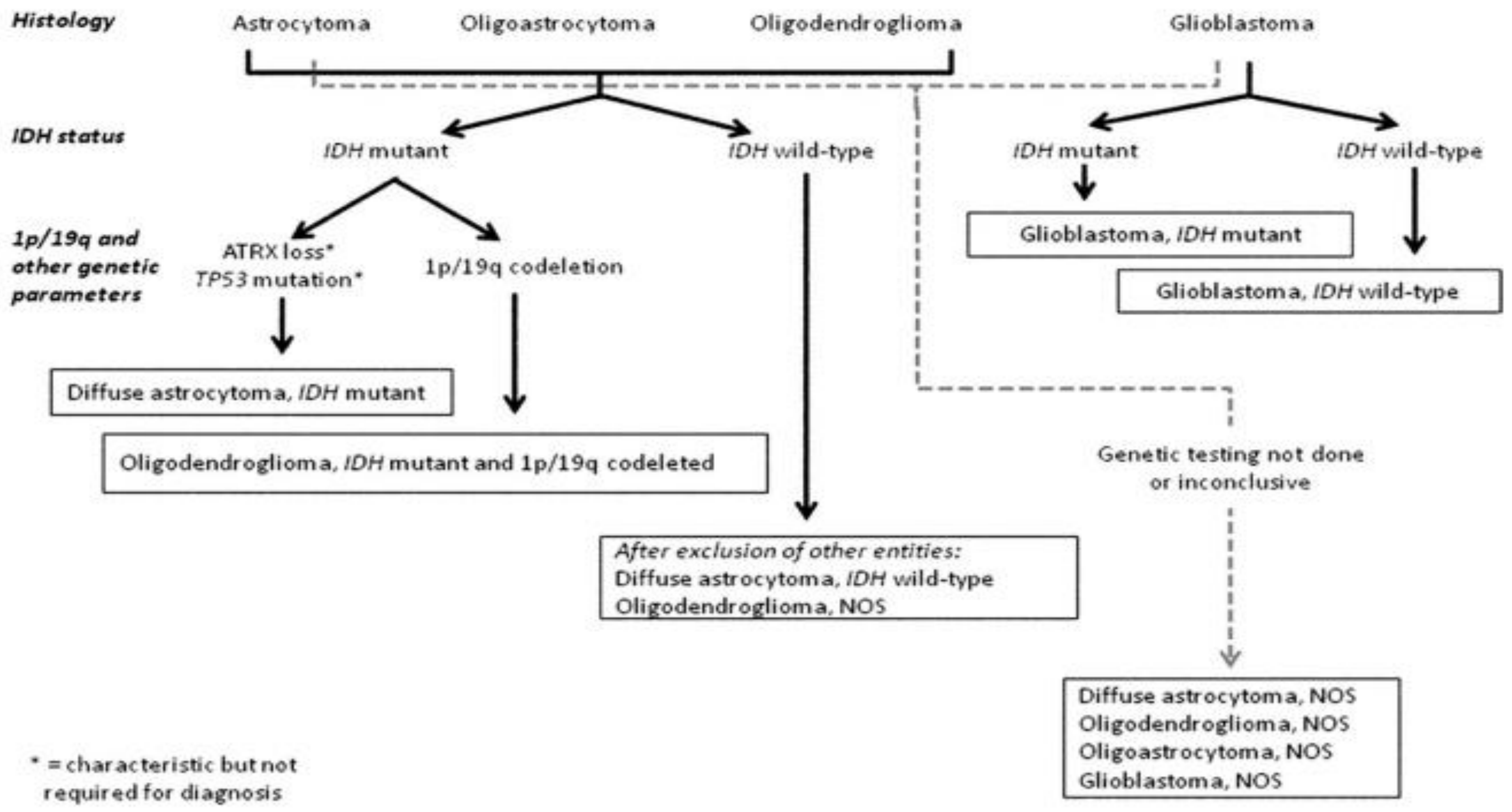


Fig. 1 A simplified algorithm for classification of the diffuse gliomas based on histological and genetic features (see text and 2016 CNS WHO for details). A caveat to this diagram is that the diagnostic "flow" does not necessarily always proceed from histology first to molecular genetic features next, since molecular signatures can sometimes outweigh histological characteristics in achieving an "integrated" diagnosis. A similar algorithm can be followed for anaplastic-level diffuse gliomas; * Characteristic but not required for diagnosis. Reprinted from [27], with permission from the WHO

GLIOMA-PRTOCOL

- CTV1(GTV+1-2Cm)-60Gy/30-33#
- CTV2(GTV+_ ED+2-3Cm)-50Gy/25-30#
- TMZ-CON/ADJ-6MTH

GLIOMA-HCG PROTOCOL-SIB-CKBoost

PHASE 1

- 50-54Gy/22-25#/5 WKS

PHASE 2

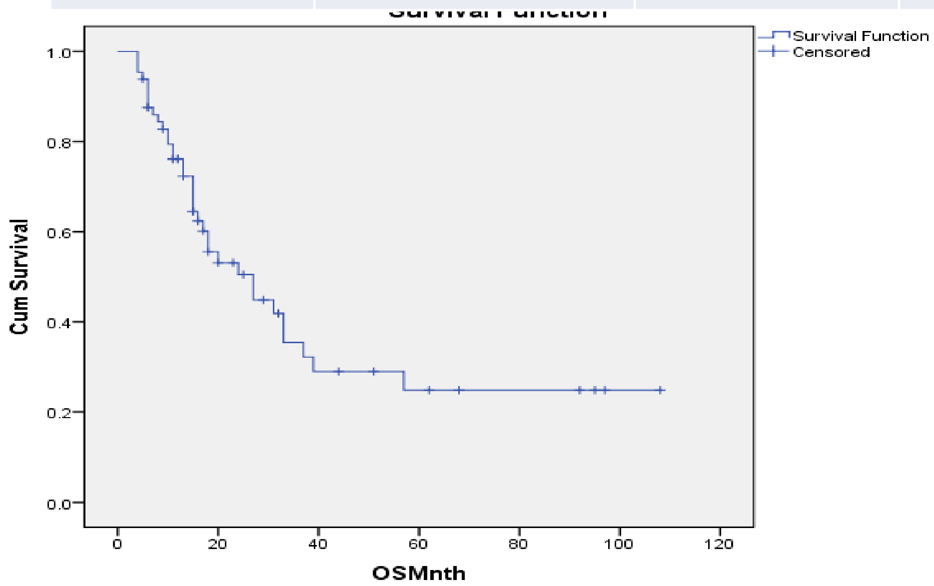
- 12-20Gy/2#/2 Days

GBM –SIB WITH CK BOOST

N=65
DOPA PET/MRI/MRS/FUN
PHASE 1-
GTVPET-54GY/25#/5WKS
GTVMR-50GY/25#/5WKS
CTV1CM-45GY/25#/5WKS
PHASE2
GTVPET/MR/CKBOOST
12-20GY/2#.BED-94.4GY
TMZ-RT/ADJ6-12MTHS
2YRS-41.3%
5YRS-14.6%

Case Processing Summary

Total N	N of Events	Censored	
65	35	30	46.2%



Median

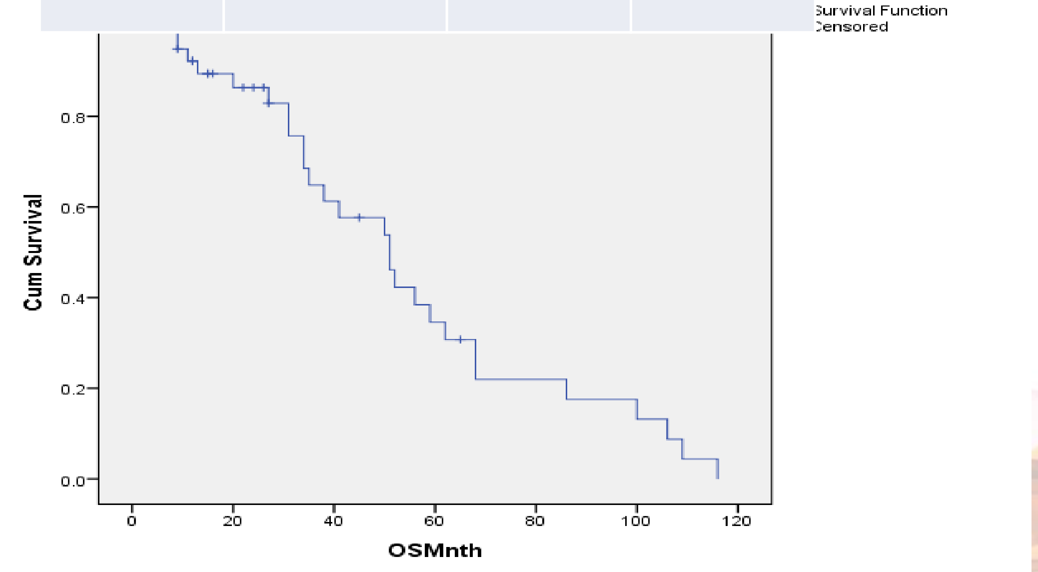
Estimate	Std. Error	95% Confidence Interval	
27.000	6.187	14.874	39.126

HGG-SIB+CKBOOST

N=39
DOPA PET/MRI/MRS/FUN
PHASE 1-
GTVPET-54GY/25#/5WKS
GTVMR-50GY/25#/5WKS
CTV1CM-45GY/25#/5WKS
PHASE2
GTVPET/MR/CKBOOST
12-20GY/2#.BED-94.4GY
TMZ-RT/ADJ6-12MTHS
2YRS-83.87%
5YRS-32.14%

Case Processing Summary

Total N	N of Events	Censored	
39	27	12	30.8%

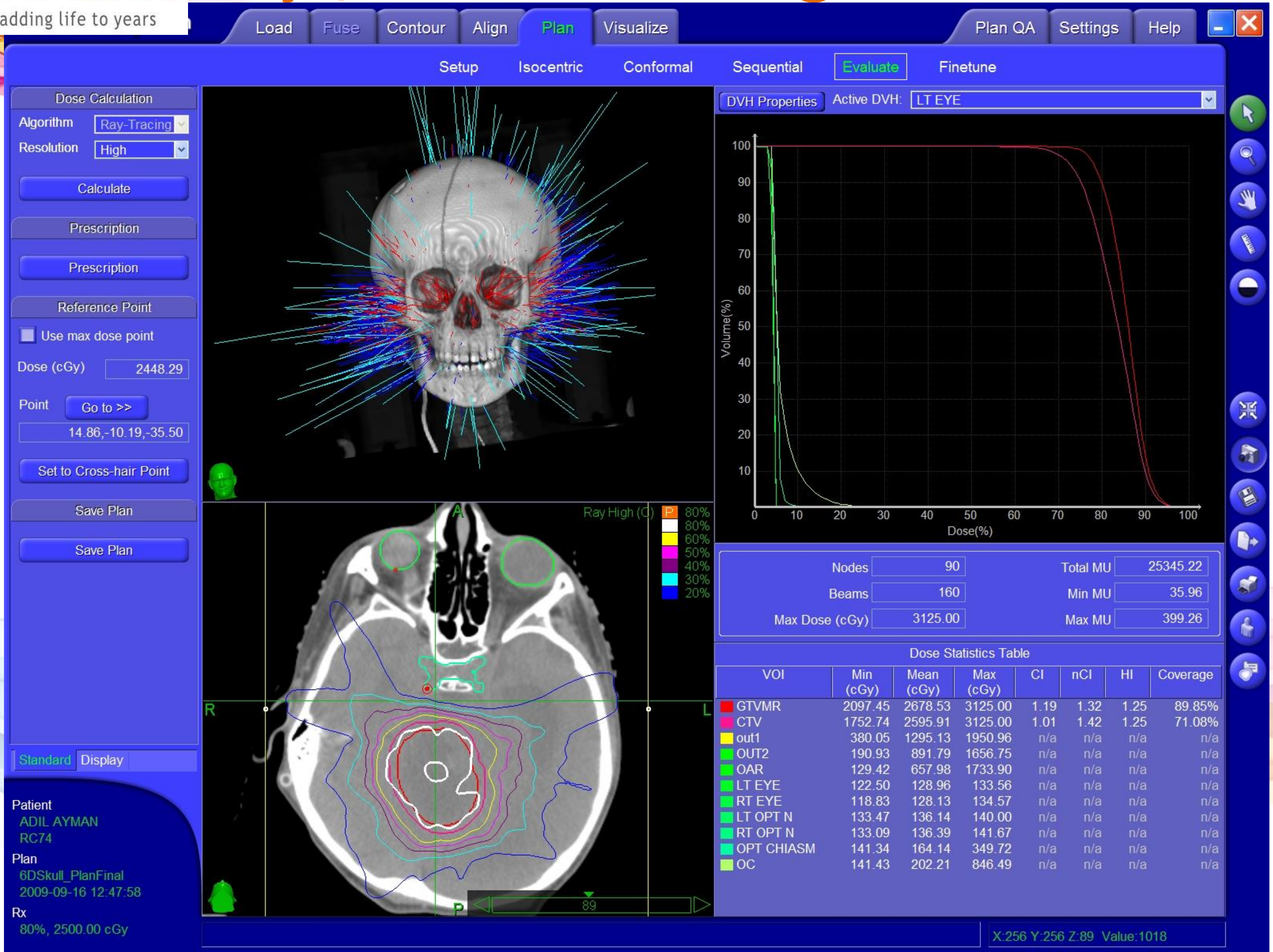


Median			
Estimate	Std. Error	95% Confidence Interval	
51.000	6.740	37.790	64.210

BSG-SIB+CKBOOST

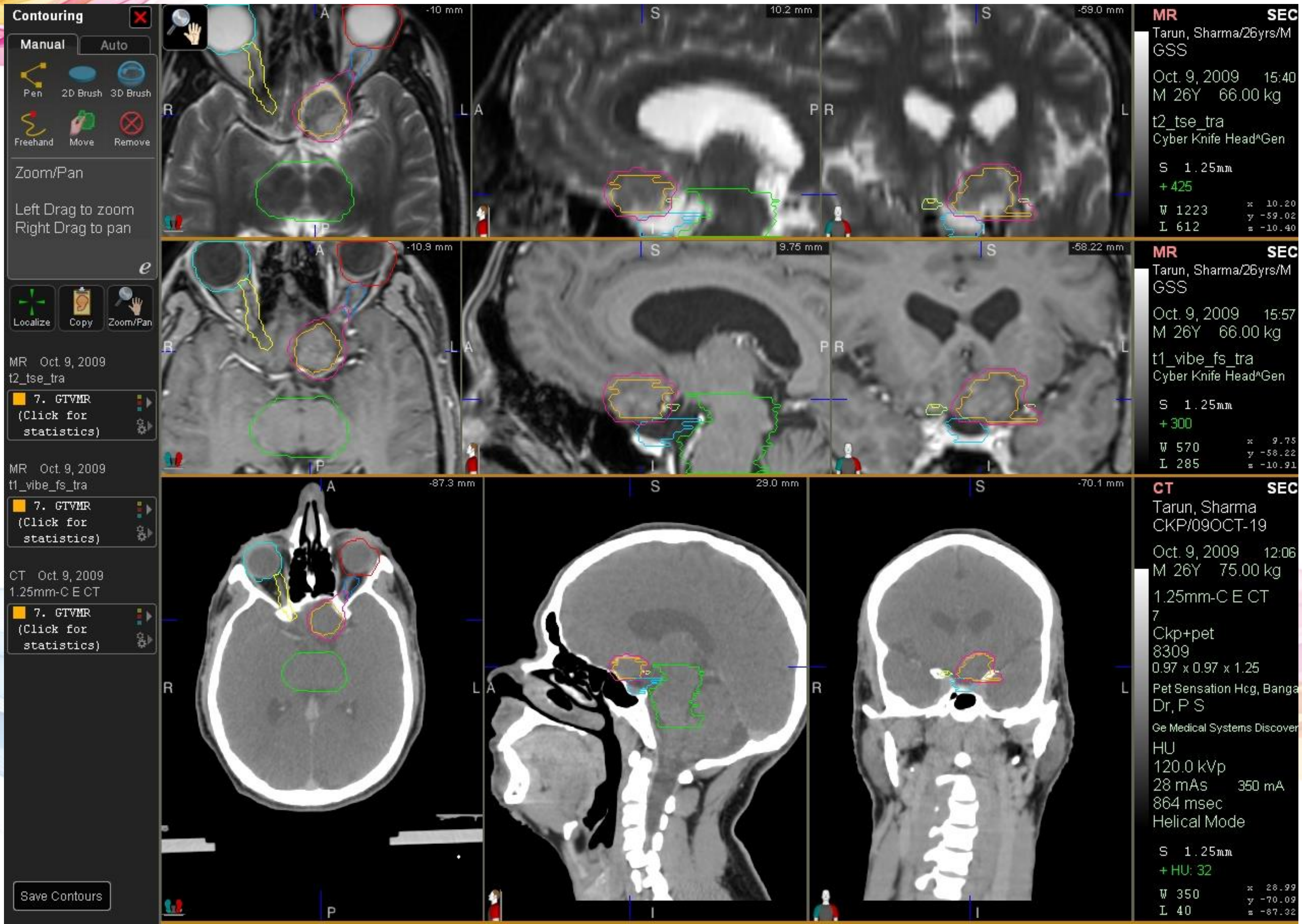
N=48
DOPA PET/MRI/MRS/FUN
PHASE 1-
GTVPET/MR-44GY/22#/5WKS
CTV-39.6GY/22#/5WKS
PHASE2
GTVPET/MR/CKBOOST
10-12GY/2#.BED-72GY
TMZ-RT/ADJ6-12MTHS
OSS-32.61MTHS SE4.852
1YRS-54.54%
2YRS-40.62%,3YRS-32.25%

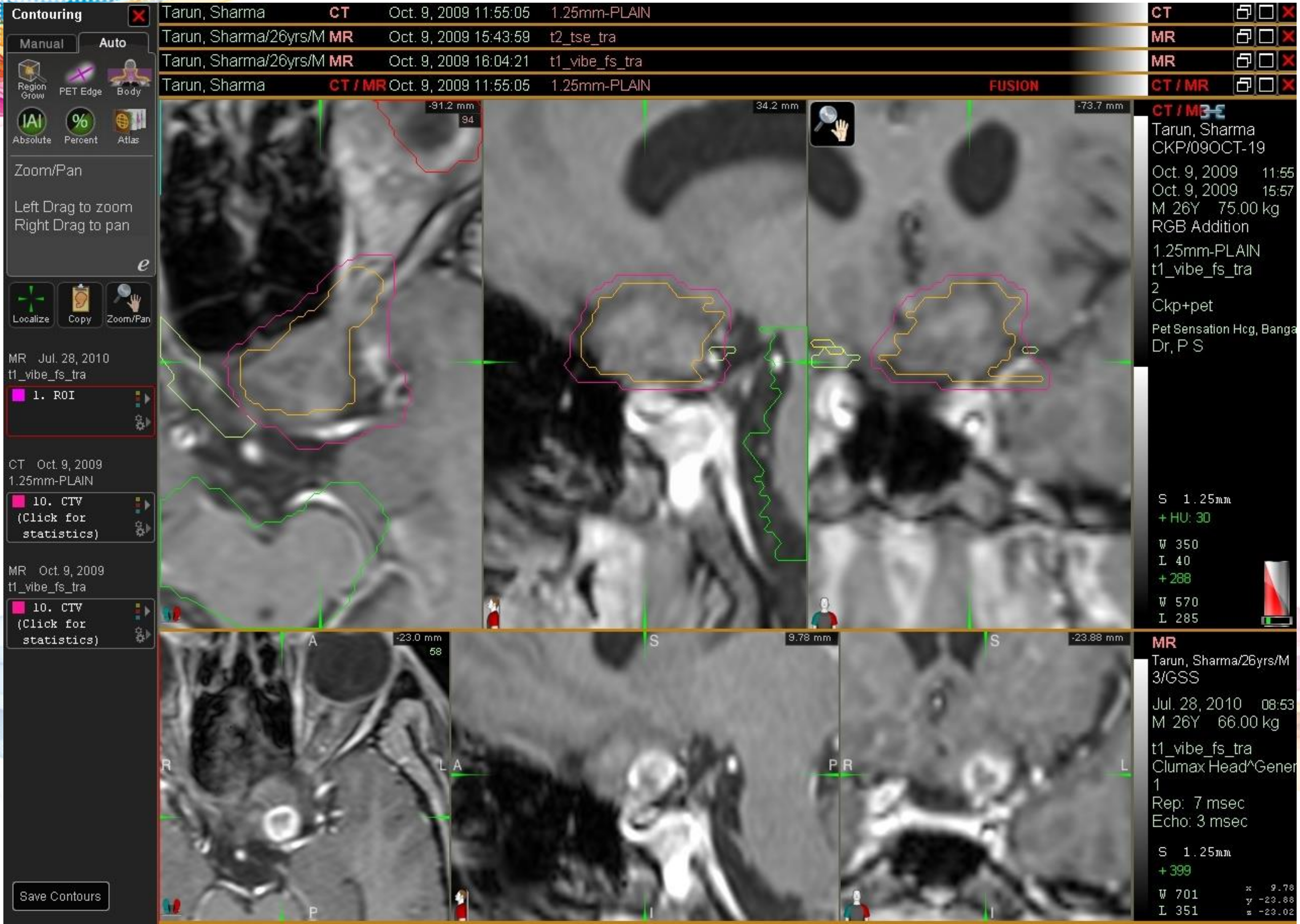
4yr/M,Brainstem glioma



VOI	Min (cGy)	Mean (cGy)	Max (cGy)	CI	nCI	HI	Coverage
GTVMR	2097.45	2678.53	3125.00	1.19	1.32	1.25	89.85%
CTV	1752.74	2595.91	3125.00	1.01	1.42	1.25	71.08%
out1	380.05	1295.13	1950.96	n/a	n/a	n/a	n/a
OUT2	190.93	891.79	1656.75	n/a	n/a	n/a	n/a
OAR	129.42	657.98	1733.90	n/a	n/a	n/a	n/a
LT EYE	122.50	128.96	133.56	n/a	n/a	n/a	n/a
RT EYE	118.83	128.13	134.57	n/a	n/a	n/a	n/a
LT OPT N	133.47	136.14	140.00	n/a	n/a	n/a	n/a
RT OPT N	133.09	136.39	141.67	n/a	n/a	n/a	n/a
OPT CHIASM	141.34	164.14	349.72	n/a	n/a	n/a	n/a
OC	141.43	202.21	846.49	n/a	n/a	n/a	n/a

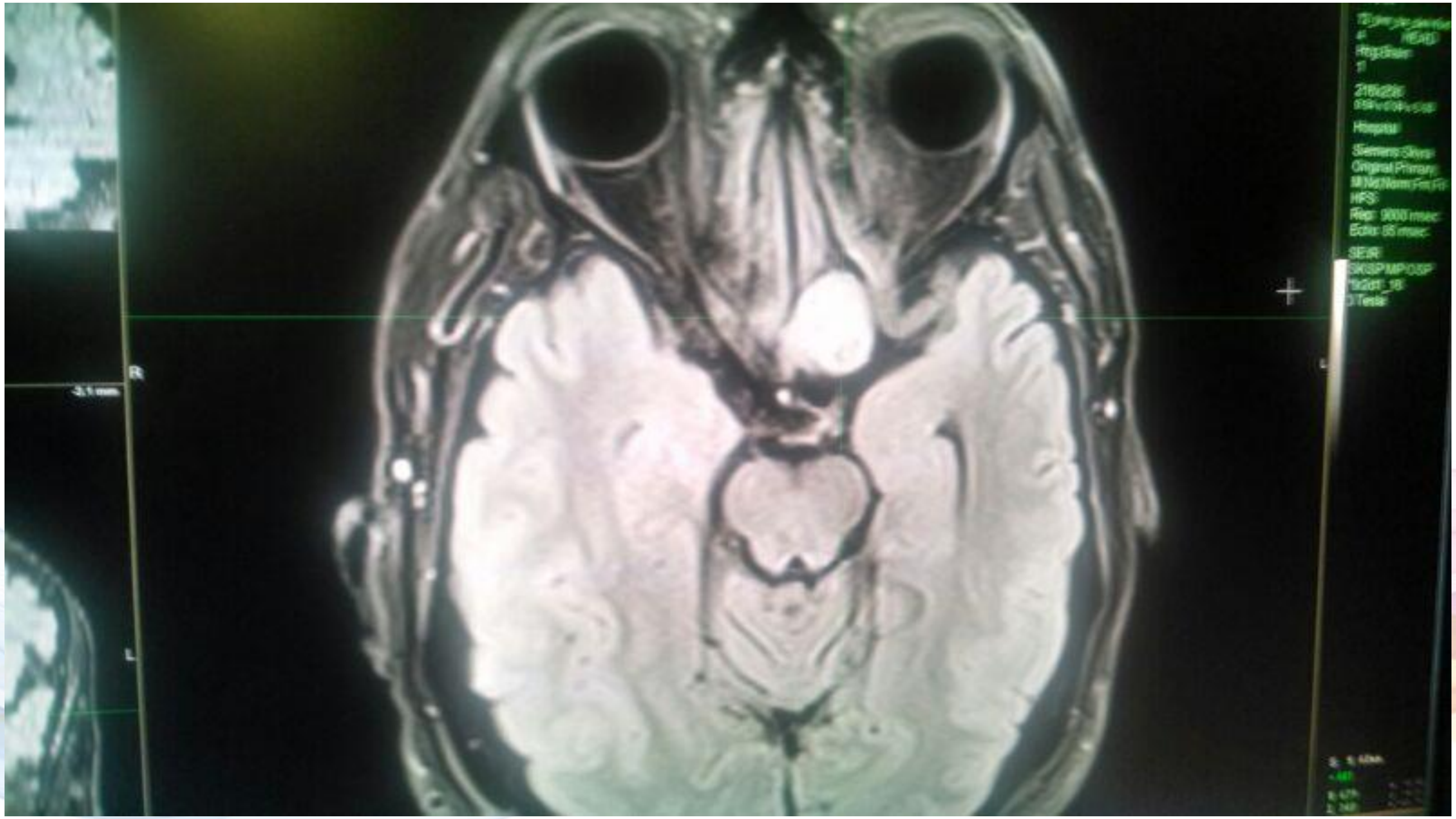
26yrs/M/opticnerve glioma



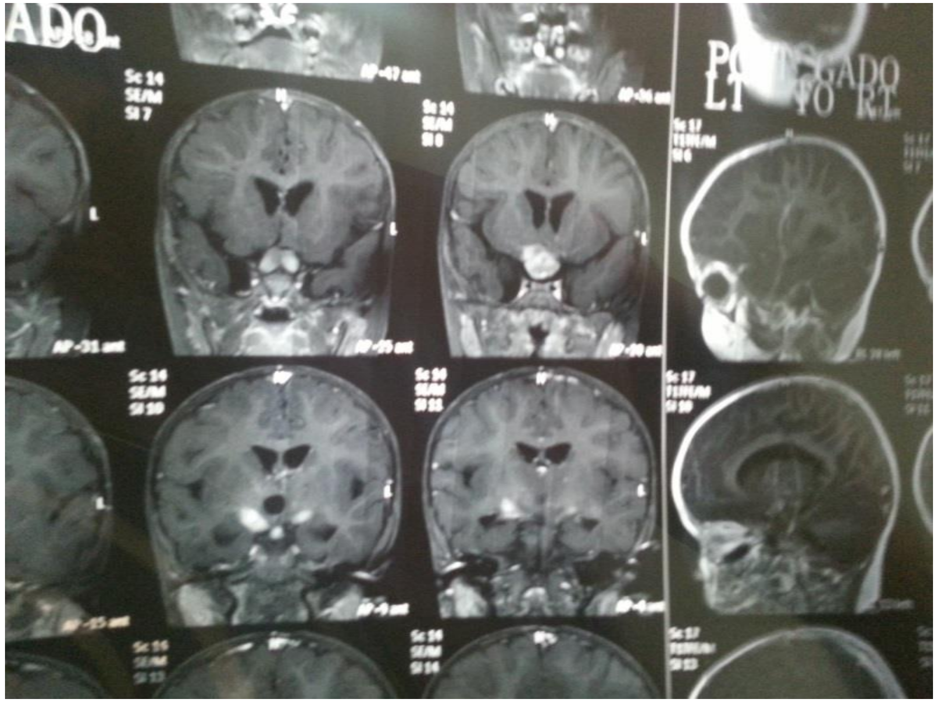


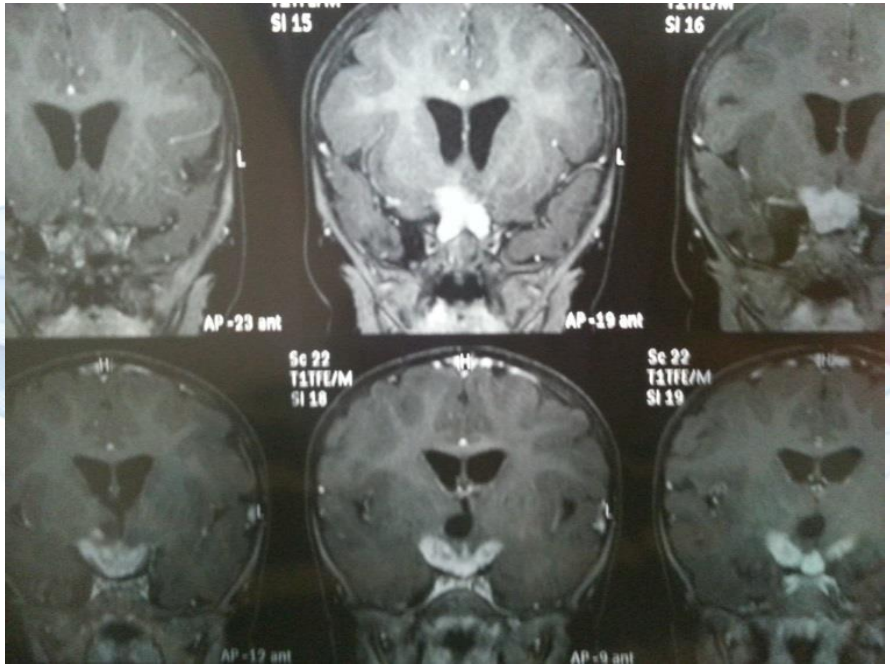
HCG Hospitals
adding life to years

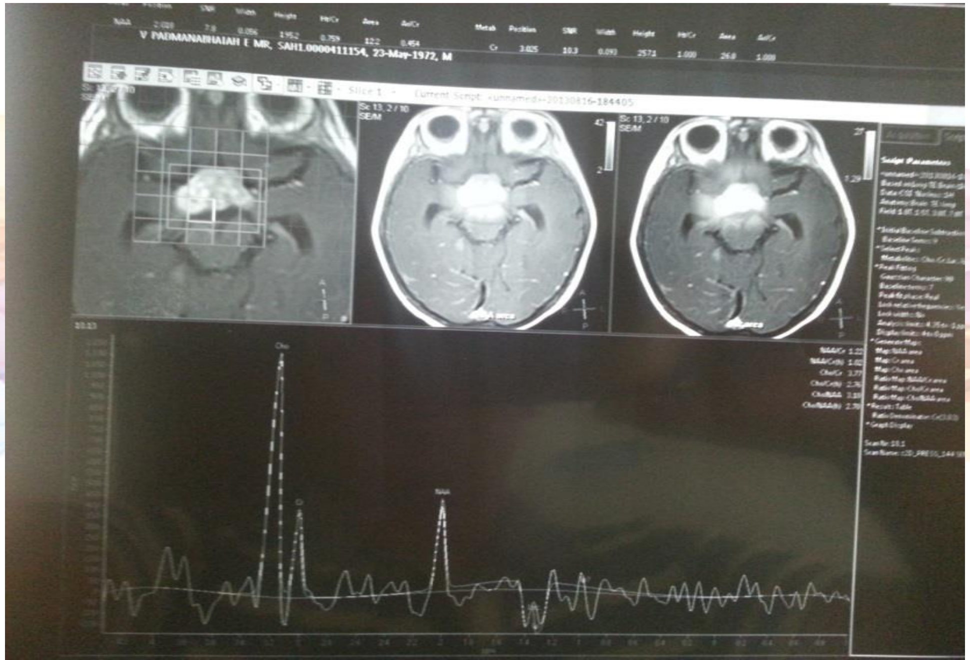
Post ck ONG 5 years



HCG Hospitals
adding life to years








New Session
New Patients
Patients
Display
-142.8 mm
1.5 mm
-77.9 mm

CONCLUSION

- SRS/SRT - 1-5 #
- GAMMA KNIFE,X-KNIFE,CYBERKNIFE
- CNS TUMORS- BENIGN,MALIGNANT,FUNCTIONAL
- BOOST,REIRRADIATION

QUESTIONS

Q.1. Who invented Cyberknife?

Q.2. How many CNS metastasis can be treated by Cyberknife?

Q.3. What is MISME Syndrome?

Q.4. BED of IGRT followed by FSRS in GBM?

Q.5. Most common postSRS side effect in Trigeminal Neuralgia?