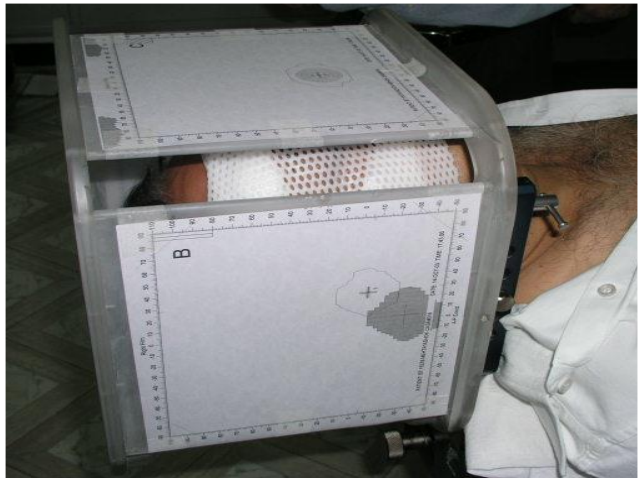


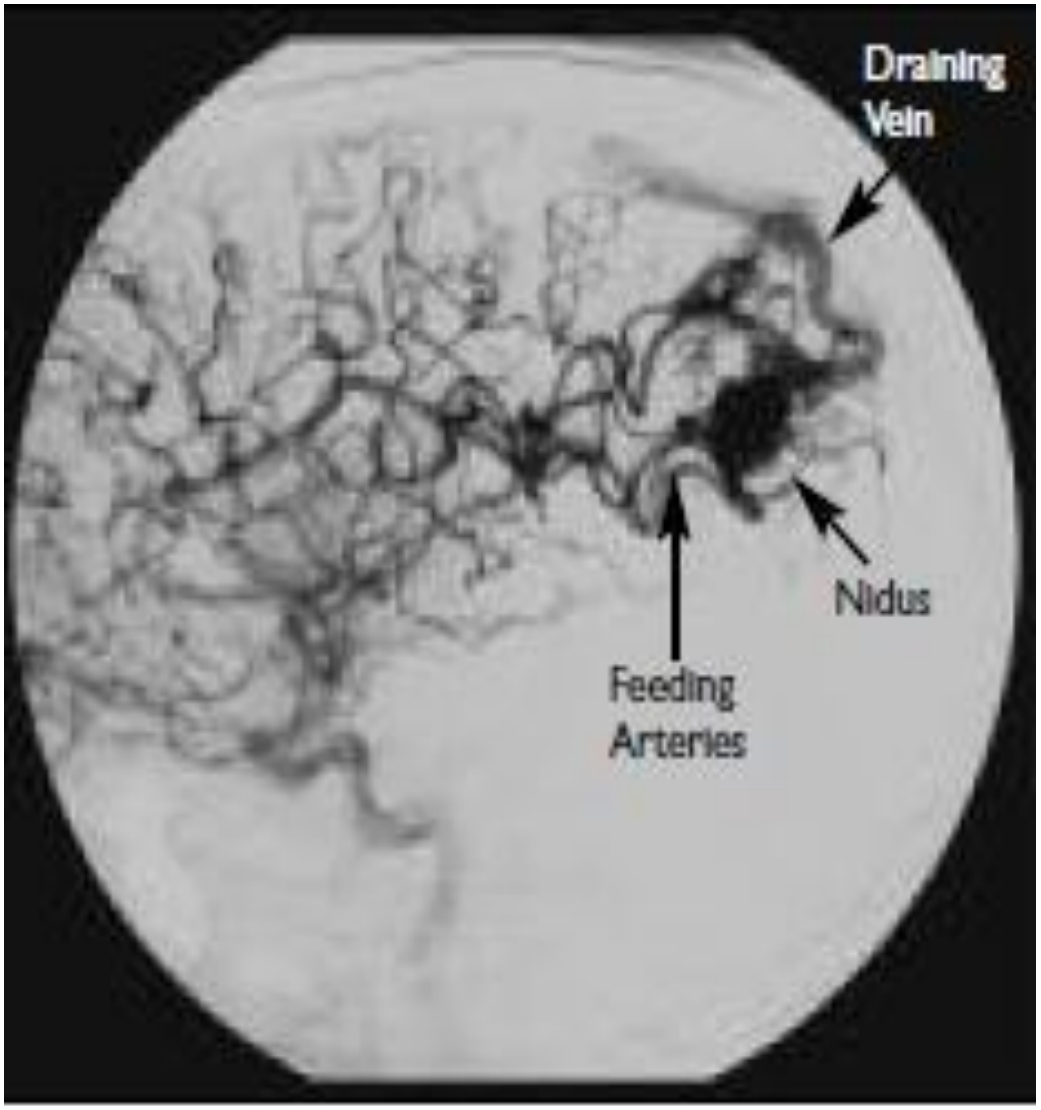
AVM: Radiosurgery

Debnarayan Dutta, MD

Professor & Head, Radiation Oncology

Amrita Institute of Medical Science, Kochi

AVM



Treatment options:

1. Surgery
2. Embolization
3. SRS
4. Observation

Rigid frame based SRS: Work Flow

Fixation of frame

DSA

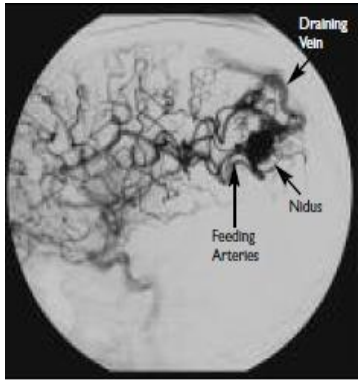
CT Scan

Image fusion

Planning

QA (LUTZ test)

Treatment



One day procedure
Need admission of patient
Frame fixed >6-8 hours

Frameless SRS: Work Flow

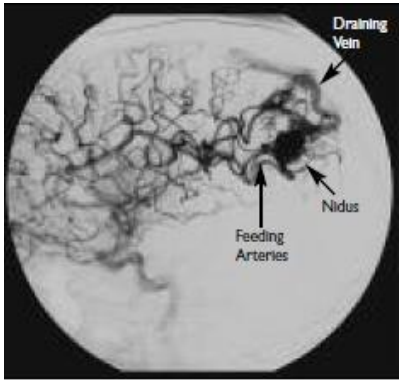
Day 1:

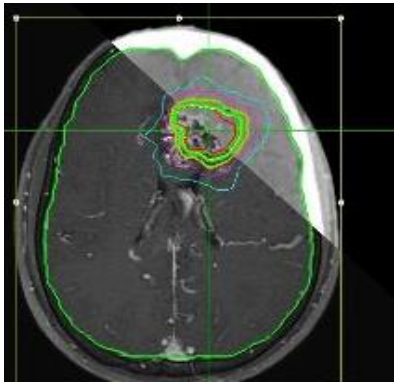
Thermoplastic mask

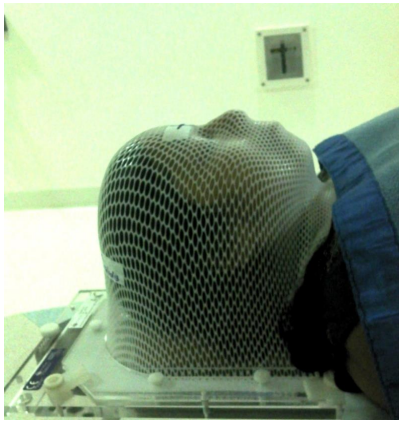
CT Angio
MR Angio
CT Scan

Image fusion
Planning

QA





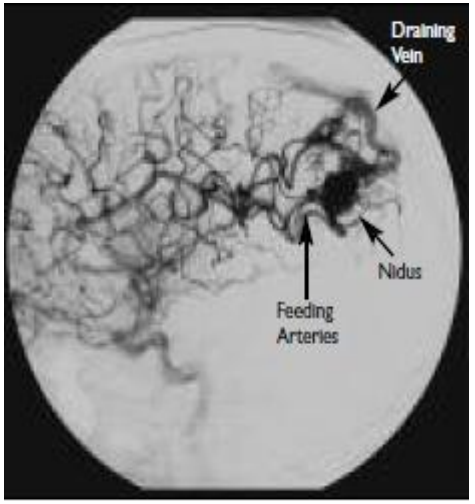


Next day:

Treatment with mask

2 days procedure
OUT PATIENT
No admission of patient

AVMs



Epidemiology

- Account for 10% SAH and 1% of strokes
- Autopsy studies show 4-5% incidence in general population
- Males: Female 2:1

Presentation

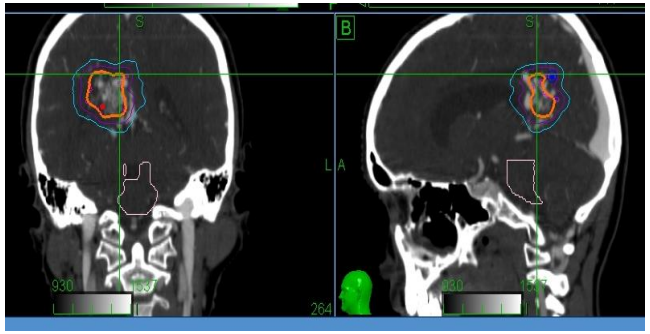
- Hemorrhage (50%) usually during 2nd-4th decades
- 10-20% risk of death if bleeds
- 10-20% risk of long-term disability
- Increased risk of re-bleed of 6% during first year after initial bleed
- Seizures (25%)
- Headache (15%) migraine-type
-Pulsatile tinnitus

Treatment

- Treatment is surgery – early cure, no need to wait for 1-2 years
-Embolization – have it's issues, may re-canalize/ partial obliterate
-SRS – an effective option, but take 2-3 years to cure

AVM: When to treat

- Deep seated AVMs
- Eloquent area AVMs
- Post-surgery residual AVM
- Post – embolization residual AVM
- Patient refuse surgery



- If AVM Bleeding: wait till blood resolves (usually 3 months)
- Symptomatic AVM (Convulsion, headache)

- Nidus size: usually <3 cm

AVM: NEED to know before treatment

- Post-SRS, need at **least 2 years to completely** obliterate (cure)
- Risk of **bleed is same**, if not more in first 2 years after SRS

- **DSA is the Gold standard** for diagnosis and response assessment
- **MRA** is close second, but usually need a DSA confirmation

- There **is no partial response** in AVM
- Either **completely cured (obliterated) or FAILED**

- **FAILURE** may be due to 1) **Inadequate contour** of nidus, 2) **Inadequate dos**e
- Nidus coverage should always be **complete**
- As high **marginal dose** possible need to be delivered
- **If partial obliteration, higher risk of bleed**

- Why we are treating – to **STOP bleeding**

AVM: Why partial obliteration is harmful ?

Higher turbulence with shrinkage of nidus

Higher risk of bleed

AVM: Prerequisites before Contouring

- **CT scan brain without & with contrast** – see bleed, location, nidus volume, mass-effect
- **Four vessel DSA** (preferable) – Arterial contributions & veinous drainage
- Nidus volume & location

Examination-

- Neurological status – Any neuro-deficit
- Any Genetic syndromes – **Sturge Weber Syndrome** etc
- ASK for duration of symptoms, history of any neuro-deficit, convulsion, headache (mass effect)

- Any **history of bleed** or any sign of recent **bleed in imagin**g, **withheld SRS procedure till blood gets completely resolved**
- Nidus volume will change with blood clot

TO DO-

1. ALWAYS study DSA (mostly **2D images**) images with **interventional radiologist & surgeon**
2. Evaluate ALL the **phases** – filling, draining
3. Review the **site of lesion** – eloquent area, motor cortex etc
4. Approximate 2 D volume estimation
5. **Inform patients: it will take 2 years at least to respond, may bleed in first 2 years after SRS**

Have a **plan in mind** before starting the procedure

AVM: know from DSA

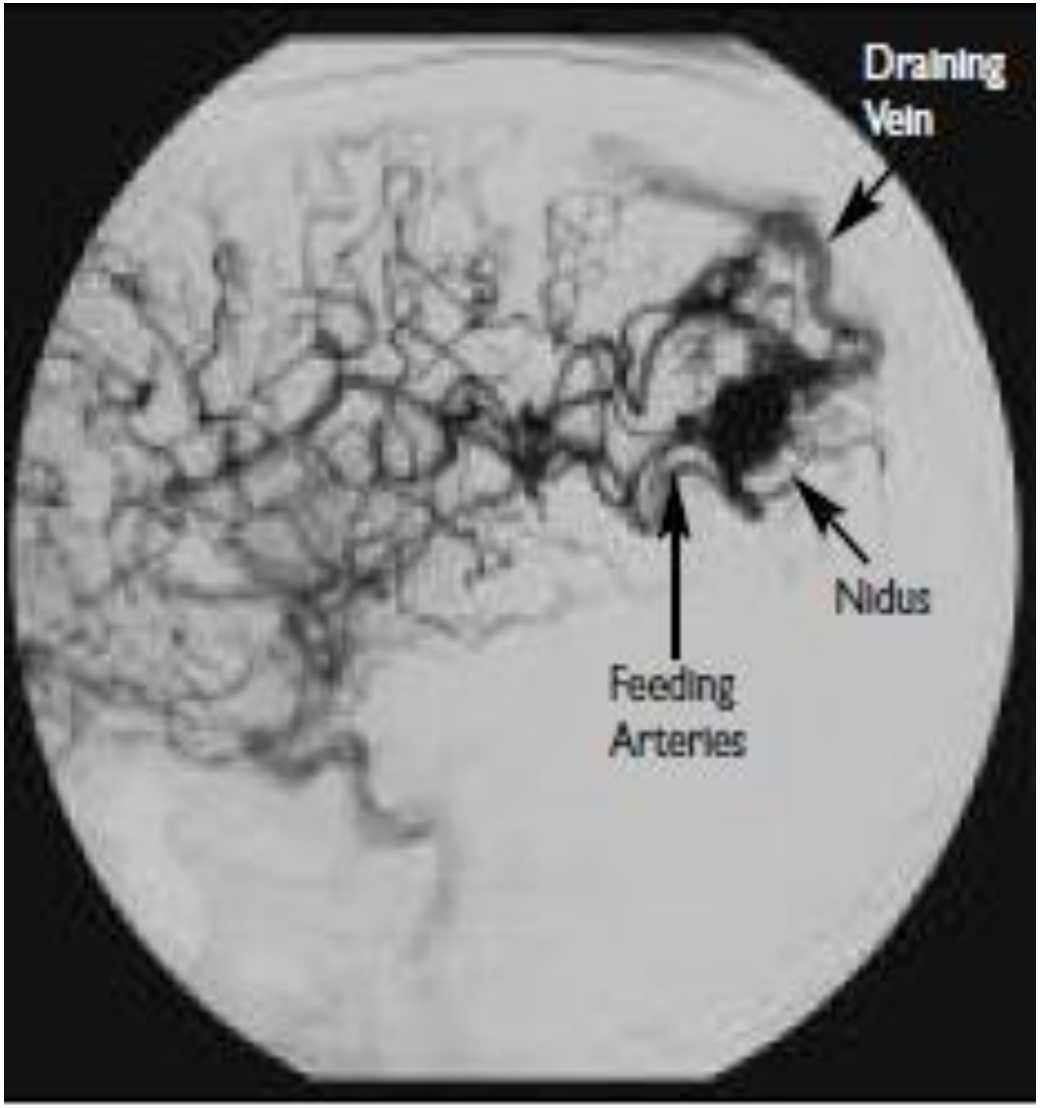
From DSA / MRA / CT scan:
-**Location** of the nidus
-**Feeding vessels** – cerebral circulation or vertebral circulation contribution
-Anterior circulation / posterior circulation / dual
-**Supplied by** – anterior cerebral, middle or posterior cerebral artery

NEED to know the supply to **locate the nidus & junction of artery & nidus**

-**Drainage** – Superficial drainage, deep drainage or dual
-**Flow rate -** High flow or slow flow circulation

-Nidus volume & extent
-Overlying vessels

-Critical structure nearby


Draining
Vein
Nidus
Feeding
Arteries

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DoB: 15/11/1977
Position: hfs
15/11/2017
12:03:11
No: 302

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C: 2047

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BINDU
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Position: hfs
15/11/2017
12:03:58
No: 303

NEURO AIMS
AXIOM-Artis

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C: 2047

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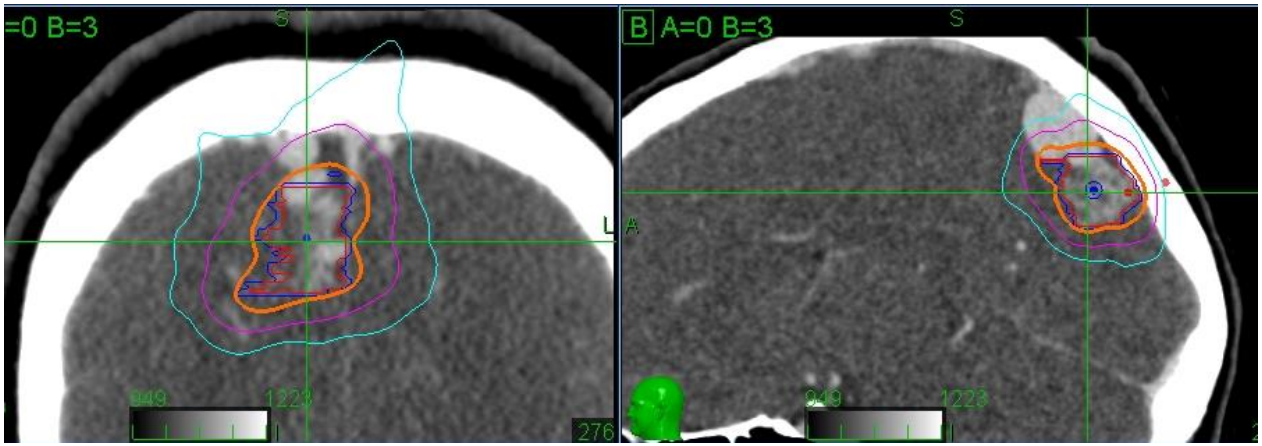
AVM: Contouring

- **Nidus volume** include: **COMPLETE nidus** in delayed phase need to be included
- Nidus volume will change with different filling & draining phase, hence **appropriate phase** need to be selected for contouring

- Ideally, **rotational angiogram** in different phase need to be fused with planning CT scan

- If not possible, take CT scan **/ CT Angio** in different phase (arterial, veinous, delayed)
- **MR Angio** done & fused with CT scan

- **Eye balling the DSA 2D films** always during contouring



AVM: Contouring

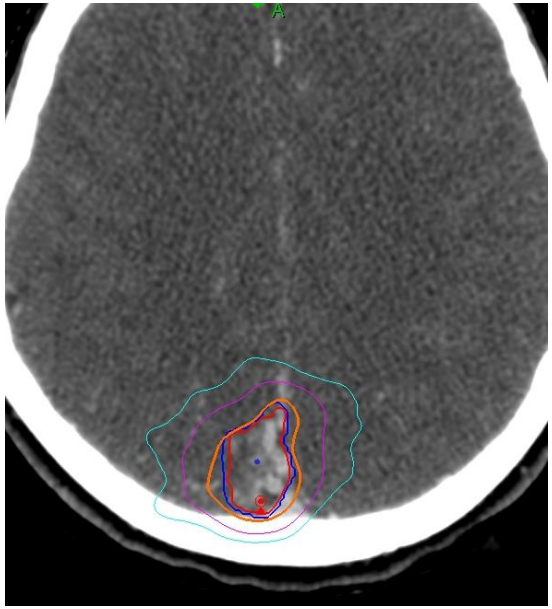
- **Nidus :** lesion seen on DSA
- **NO CTV** margin

- **PTV margin:** 0-2 mm

(depending upon setup error and treatment accuracy)

Normal brain

OARS:
Eye
Chiasm
Optic nerve
Brainstem
Spinalcord



AVM: NEED to know about Dose prescription

- There is **no dose fixed for AVM**
- In **isocentric technique**, dose prescribed at isocentre and isodose line covering the target is assessed
- **Peripheral (marginal) dose is considered important for obliteration**
- MAX dose or prescribed dose is NOT important for obliteration

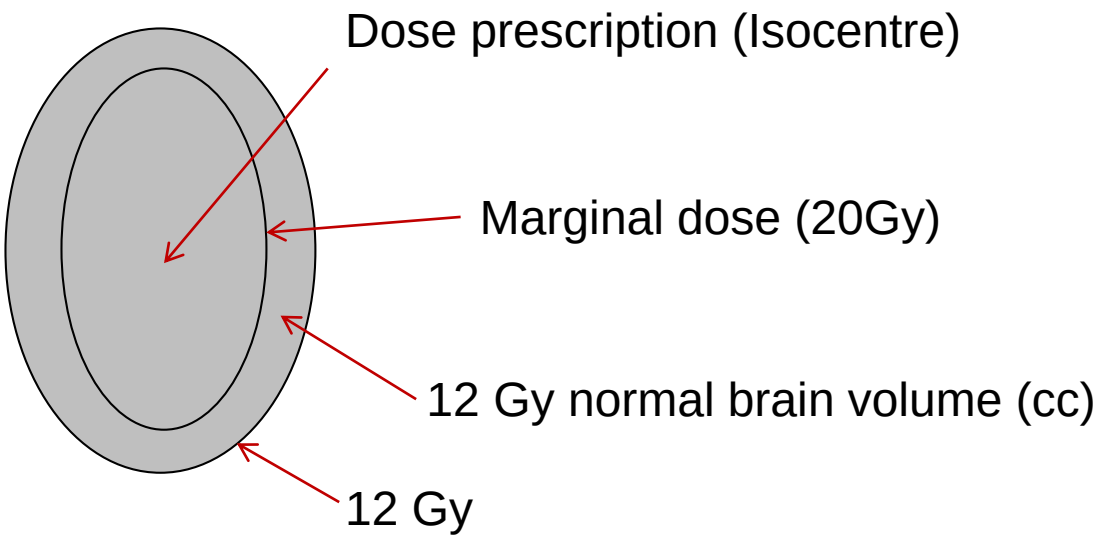
- In **multiple isocentric techniques** or in volumetric prescription, marginal dose is calculated

- Preferable **marginal dose** is **20-24 Gy**
- **Beyond 24 Gy**, no additional benefit
- **Less than 18 Gy,** obliteration rate drops significantly

- **Toxicity** (Persistent neurological deficit) depends upon **12 Gy normal brain volume**

- Dose prescription done with persistent neurological deficit probability **<5%** & obliteration rate **>80%**

AVMs: *SRS dosimetry*

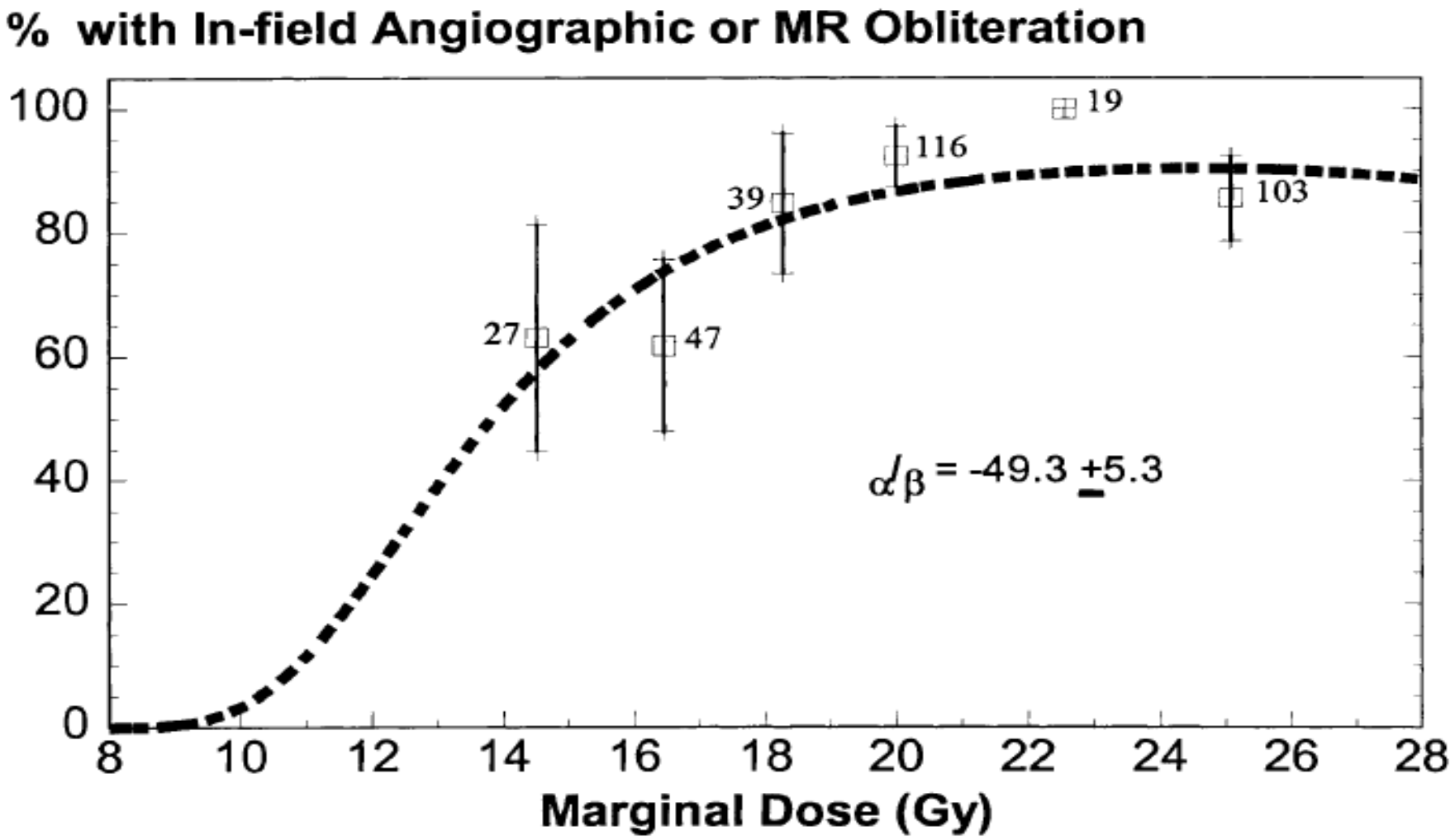


Obliteration depends upon: **marginal dose**

Complication depends upon: **12 Gy normal brain volume**

Higher precision RT: rapid dose fall-off – high marginal dose & low 12 Gy volume

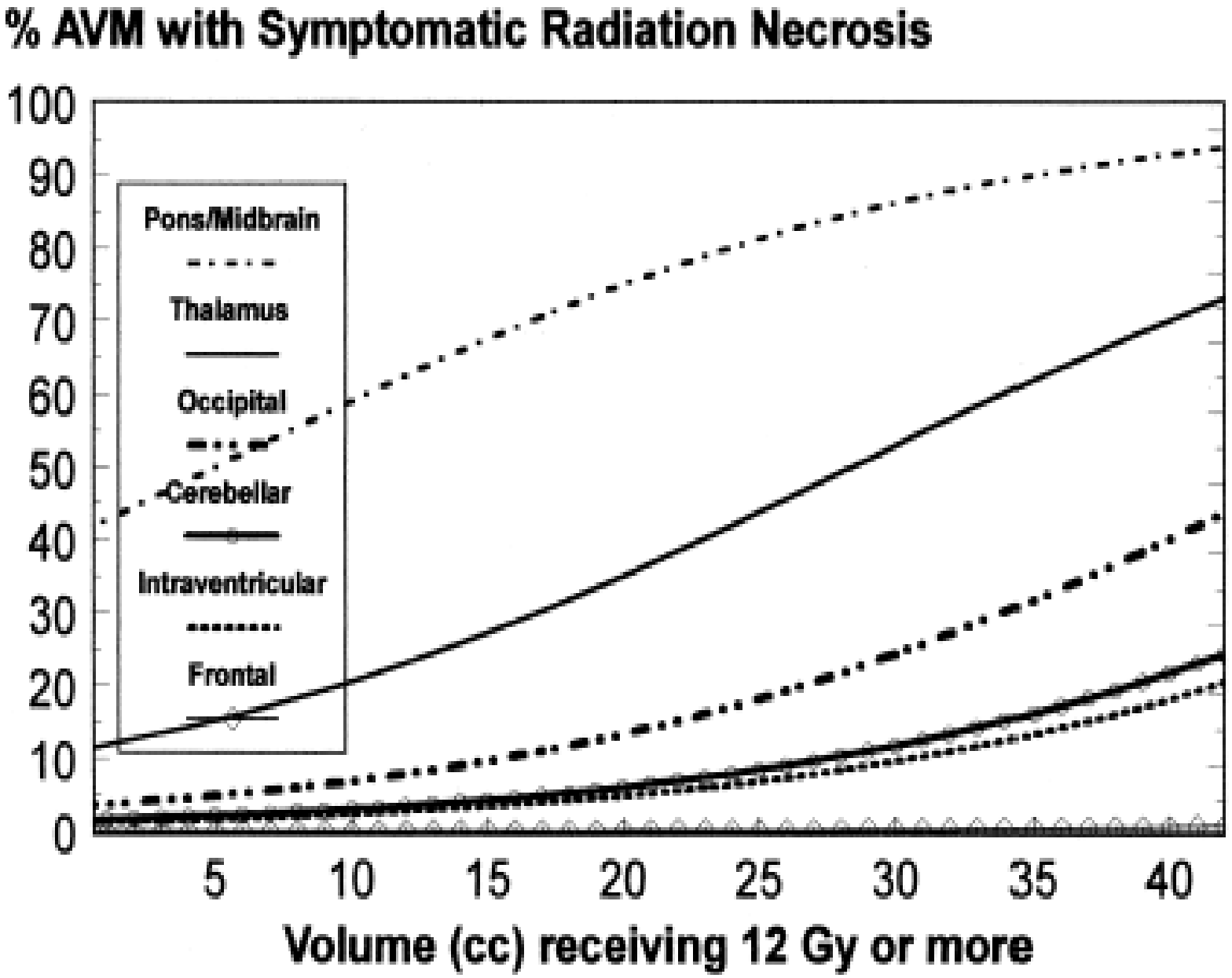
Dose response curve: obliteration rate



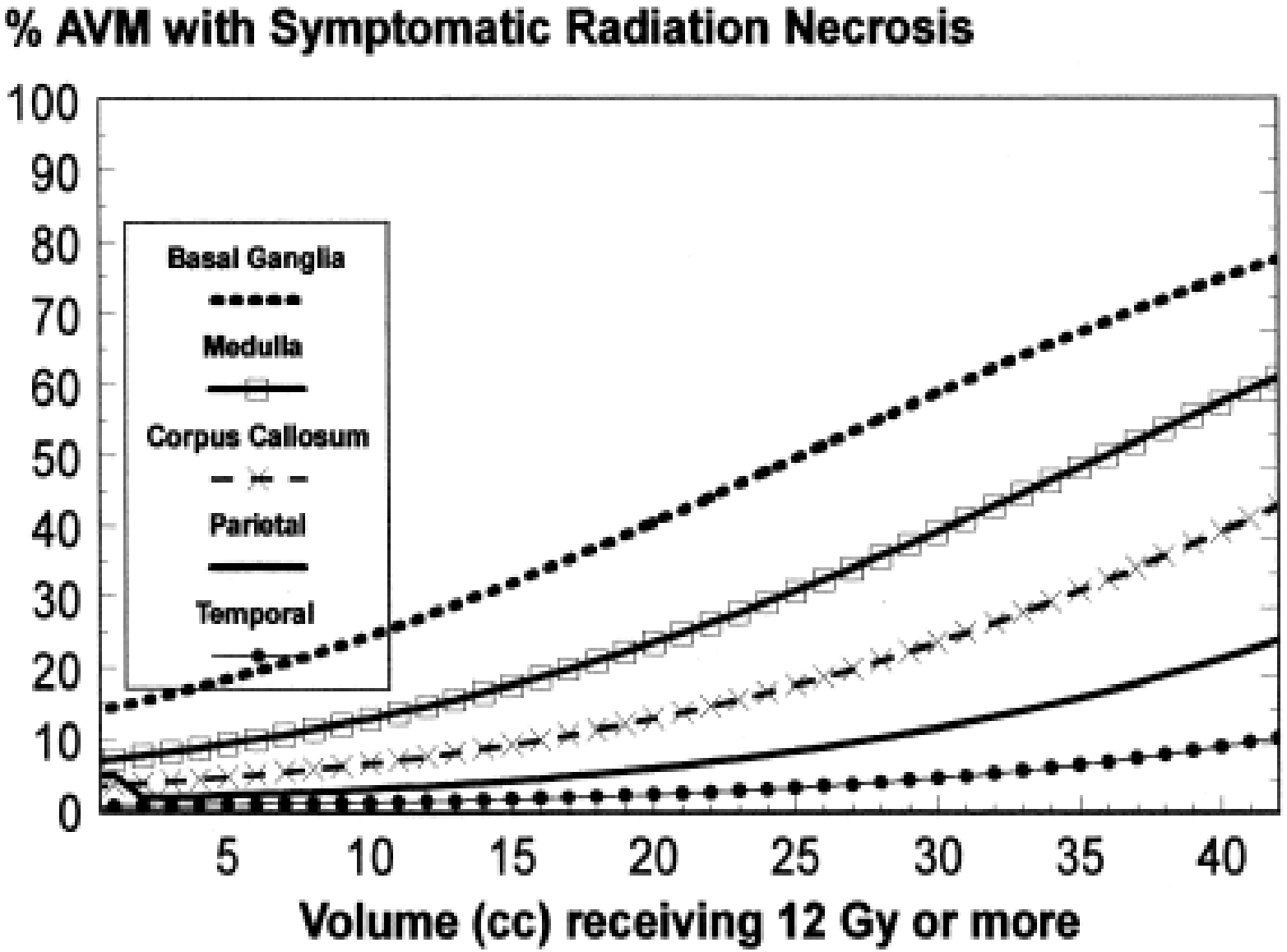
Obliteration after SRS depends upon marginal dose

Flickinger et al.. Rad Onc 2002; 63:347-354.

Long-term Toxicity



Long-term Toxicity

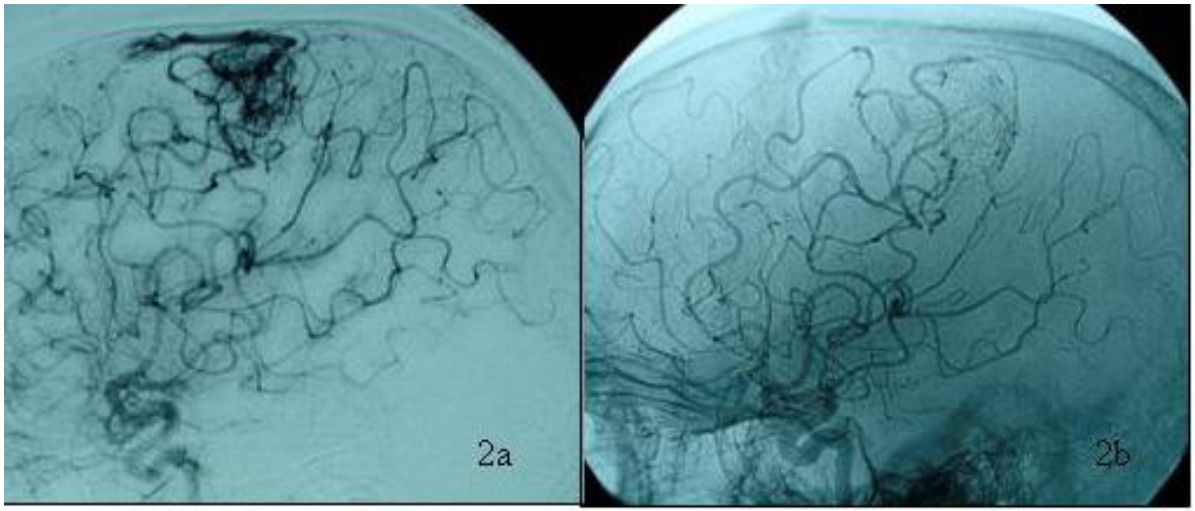


AVM: Isocentric accuracy test (LUTZ Test)

Treatment delivery: Frameless Robotic SRS in AVM

Treatment time: 20-45 min
Thermoplast based SRS
Pts received Dexa/ PPI
No acute toxicity for majority of patients (one pt had brain oedema requiring MDT)

Follow up: Protocol



Follow up:

- MRA/ MRI every 6 monthly / 12 monthly

-After MRA shows complete obliteration, **DSA needed for confirmation**

-Once obliteration is complete: **CURE. No further follow up**

-If **NOT obliterated after 2 years**, follow till **3 years** with MRA

-**Residual AVM** need **retreatment** – Surgery, embolization or re-SRS

Case 1

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15/11/2017
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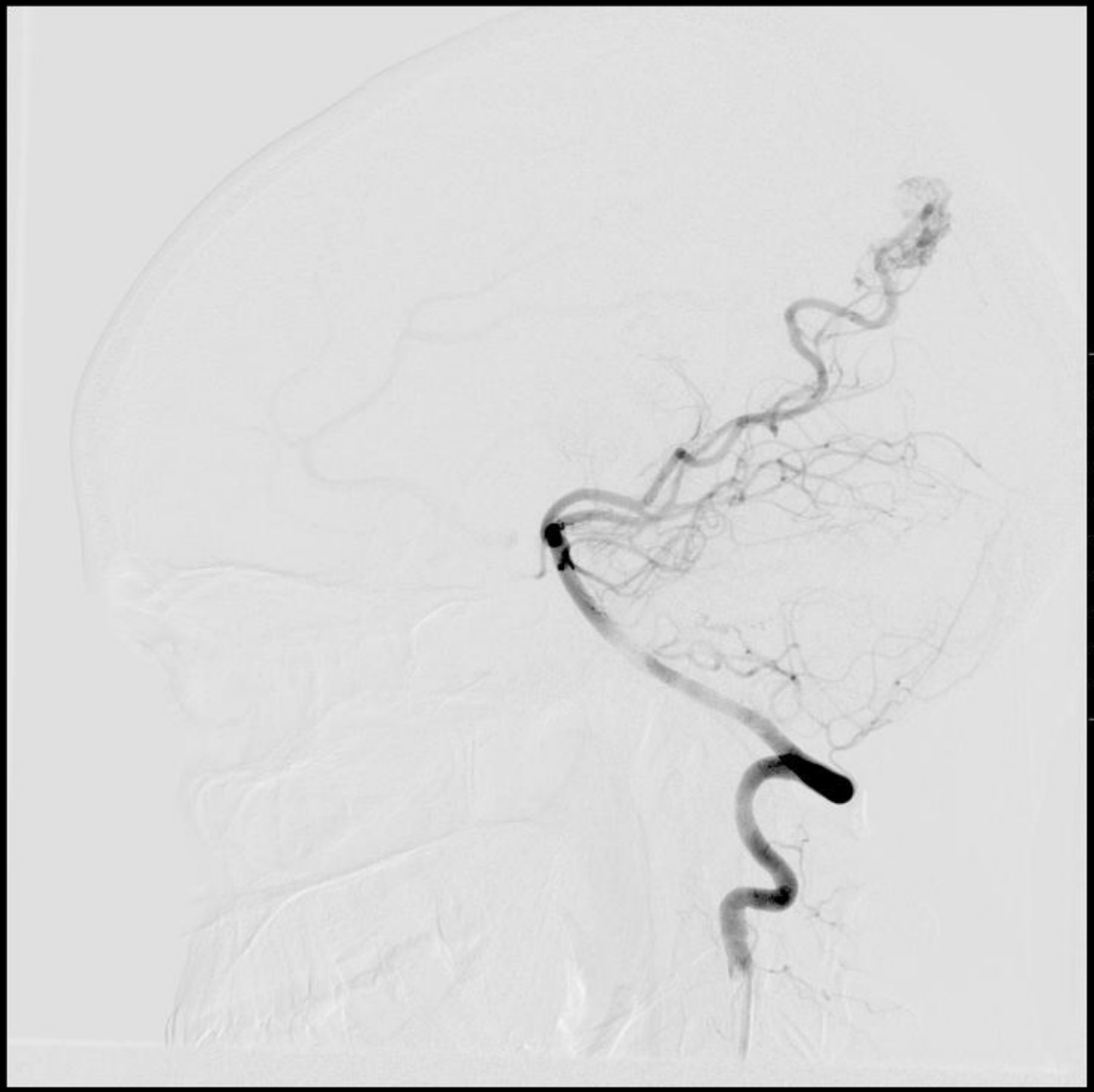

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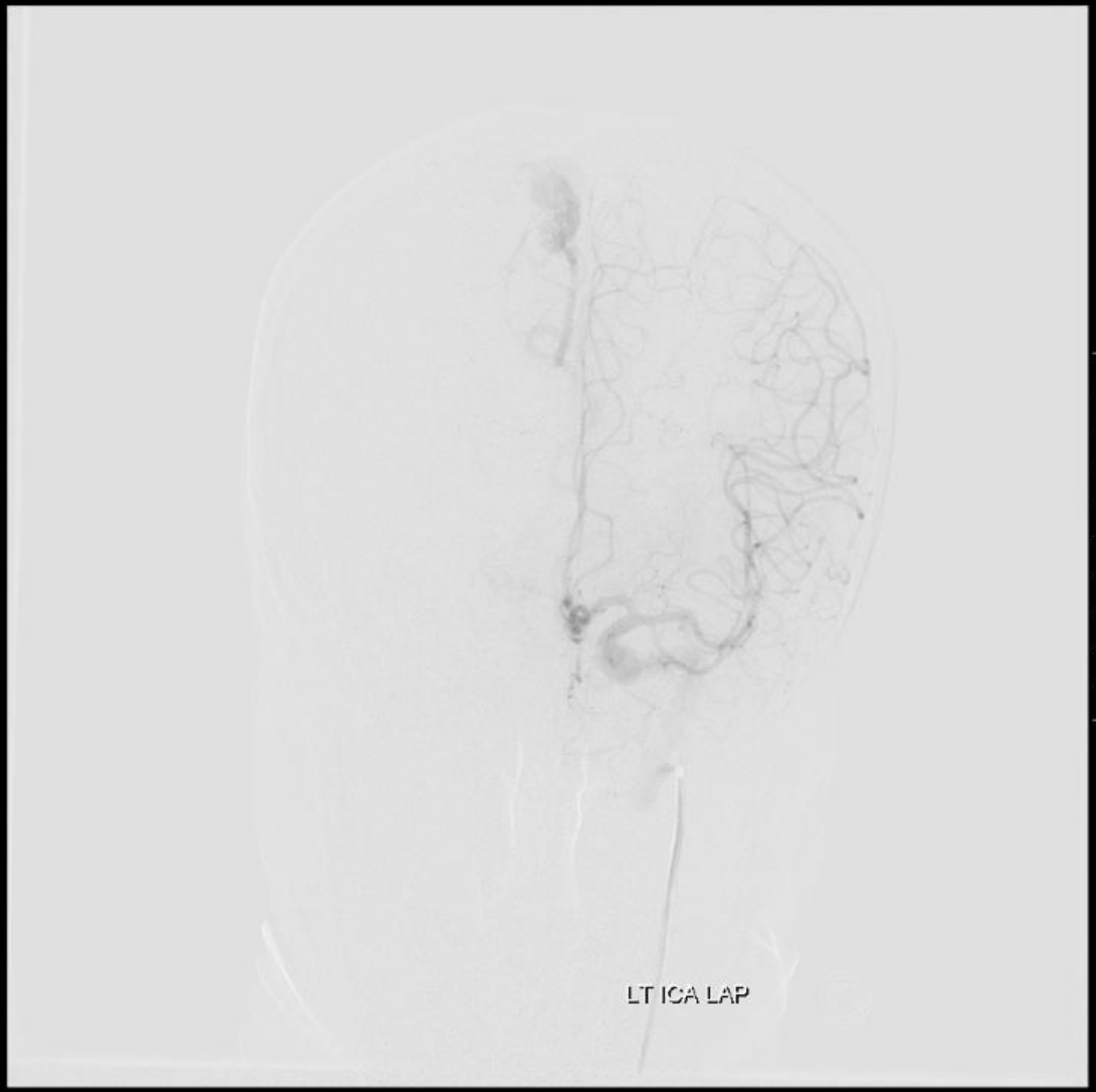

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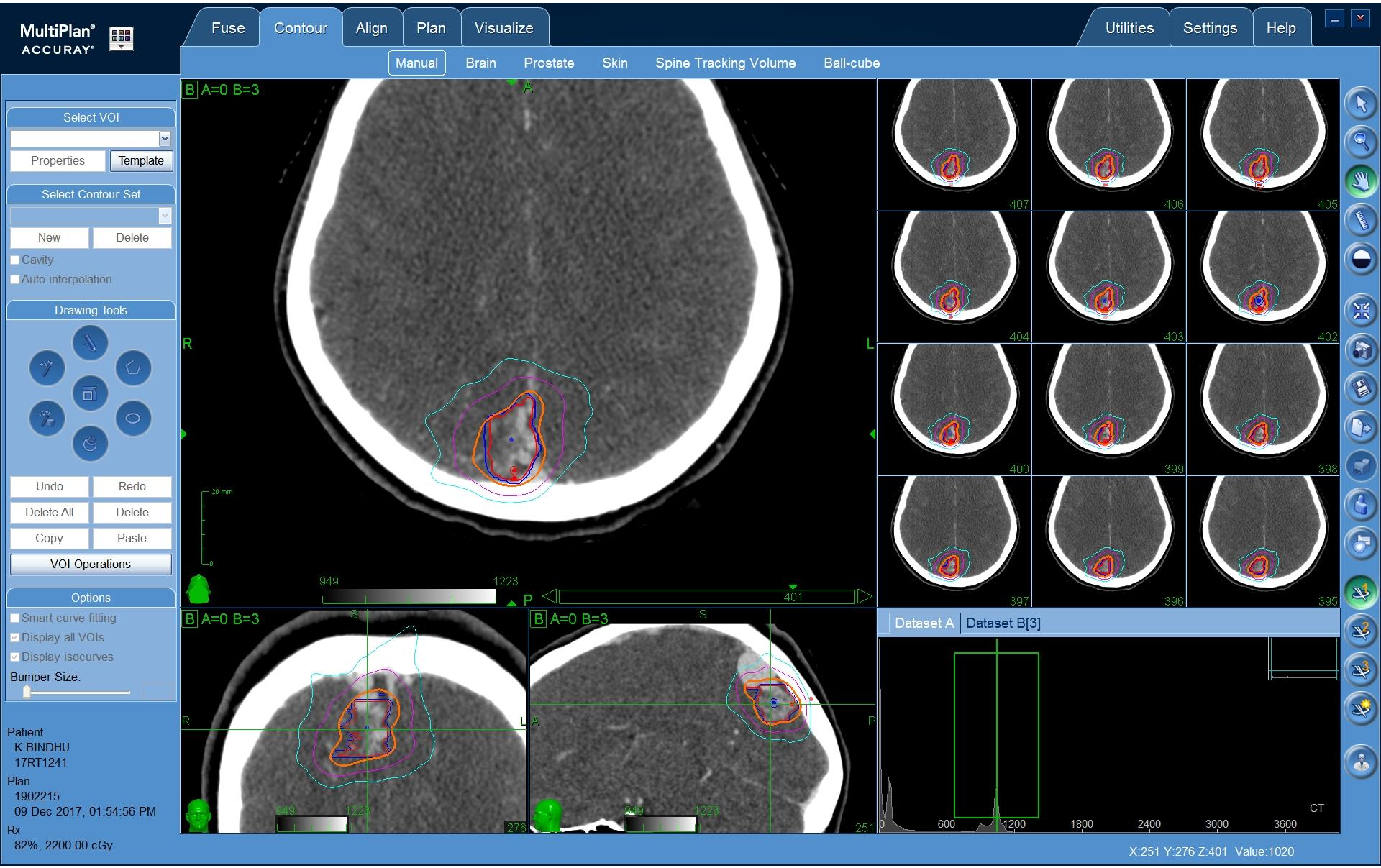
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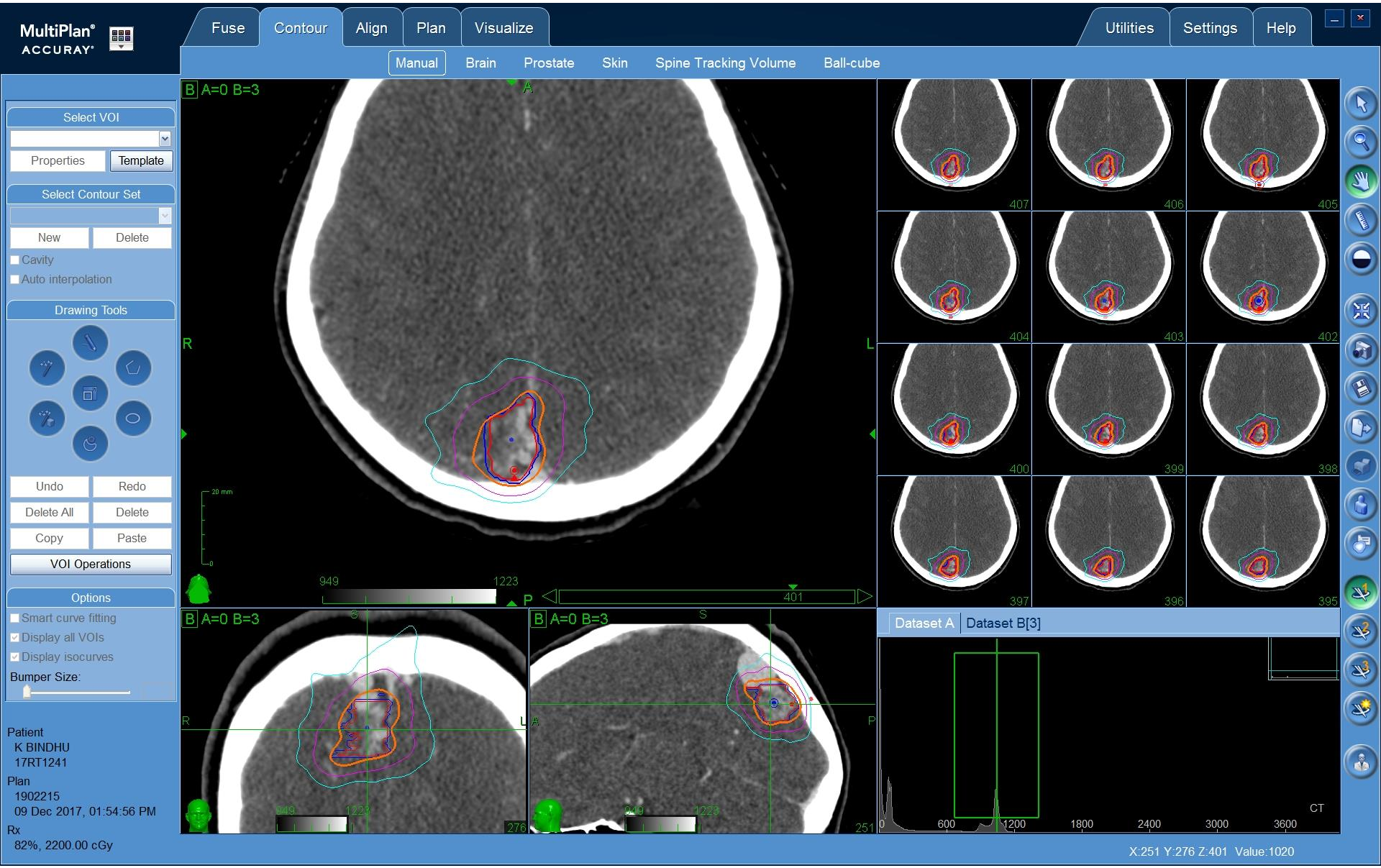
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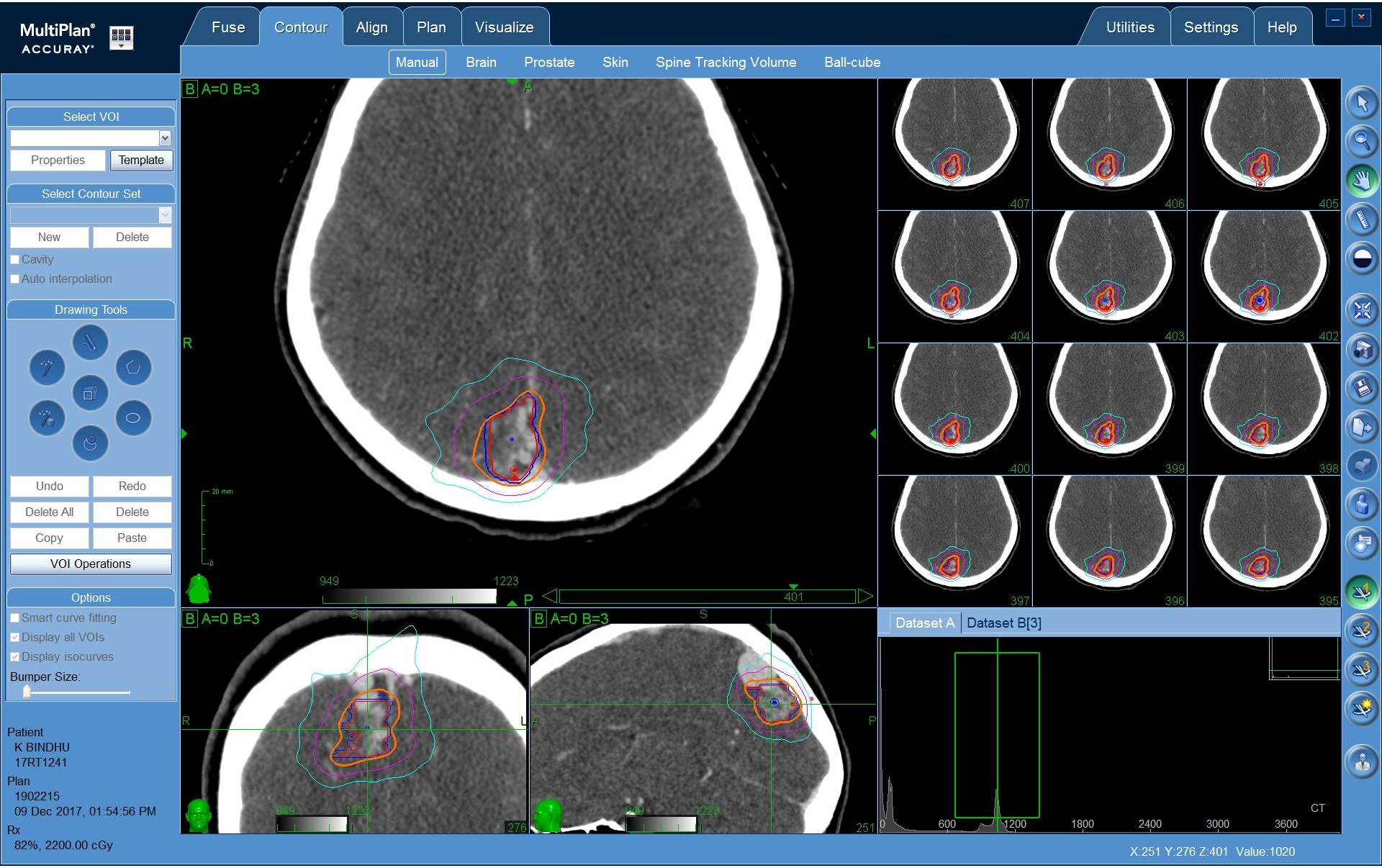
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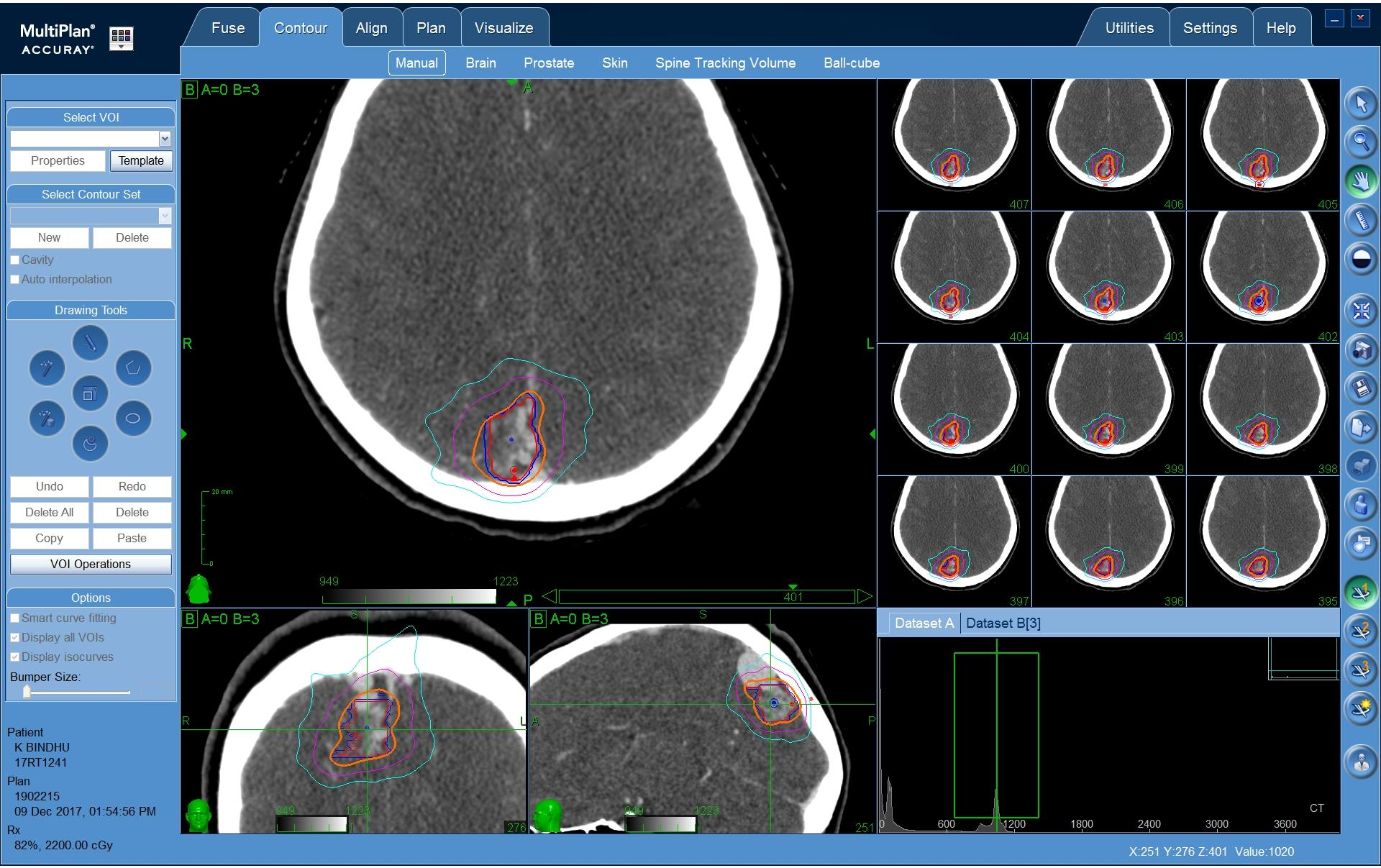
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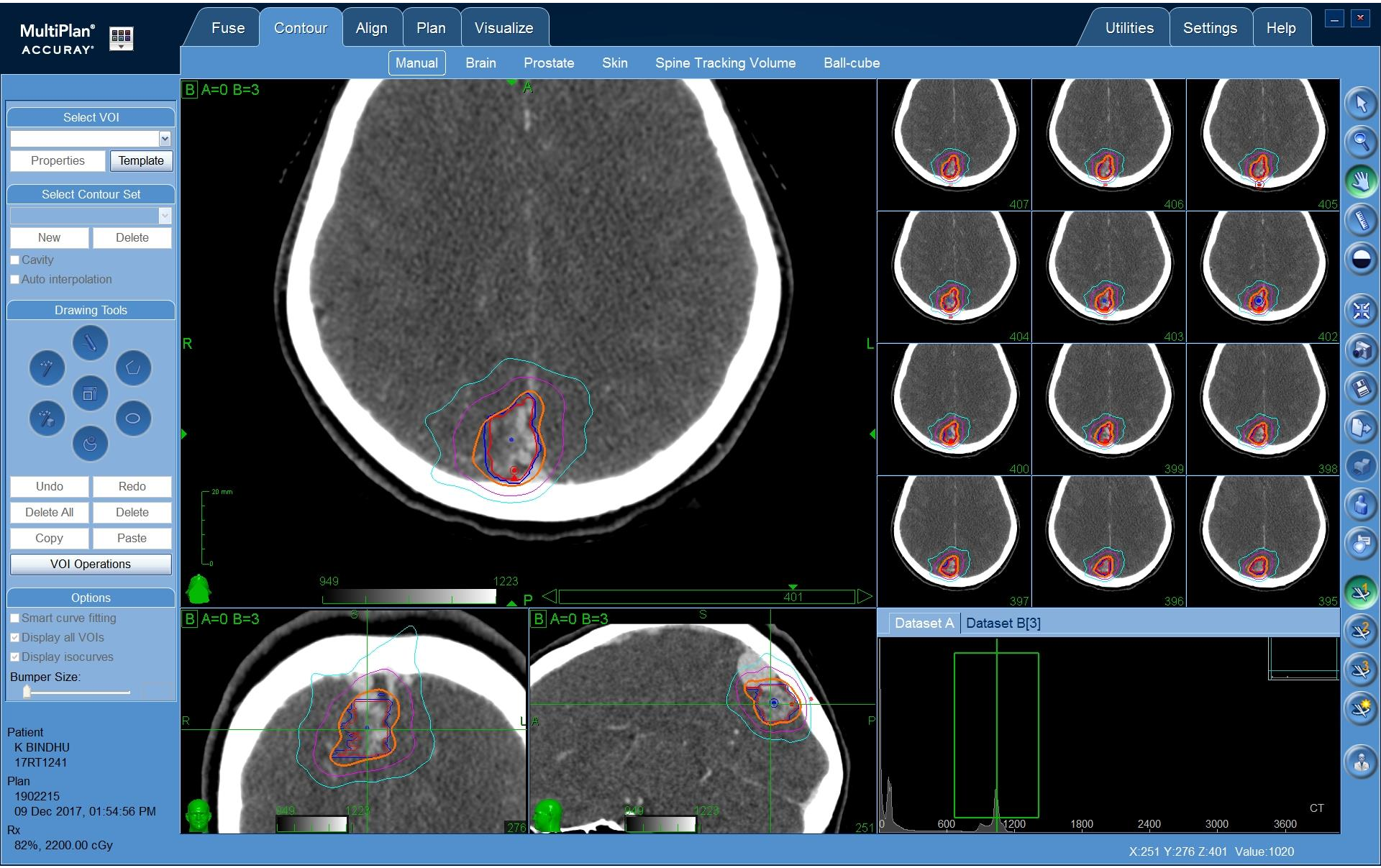
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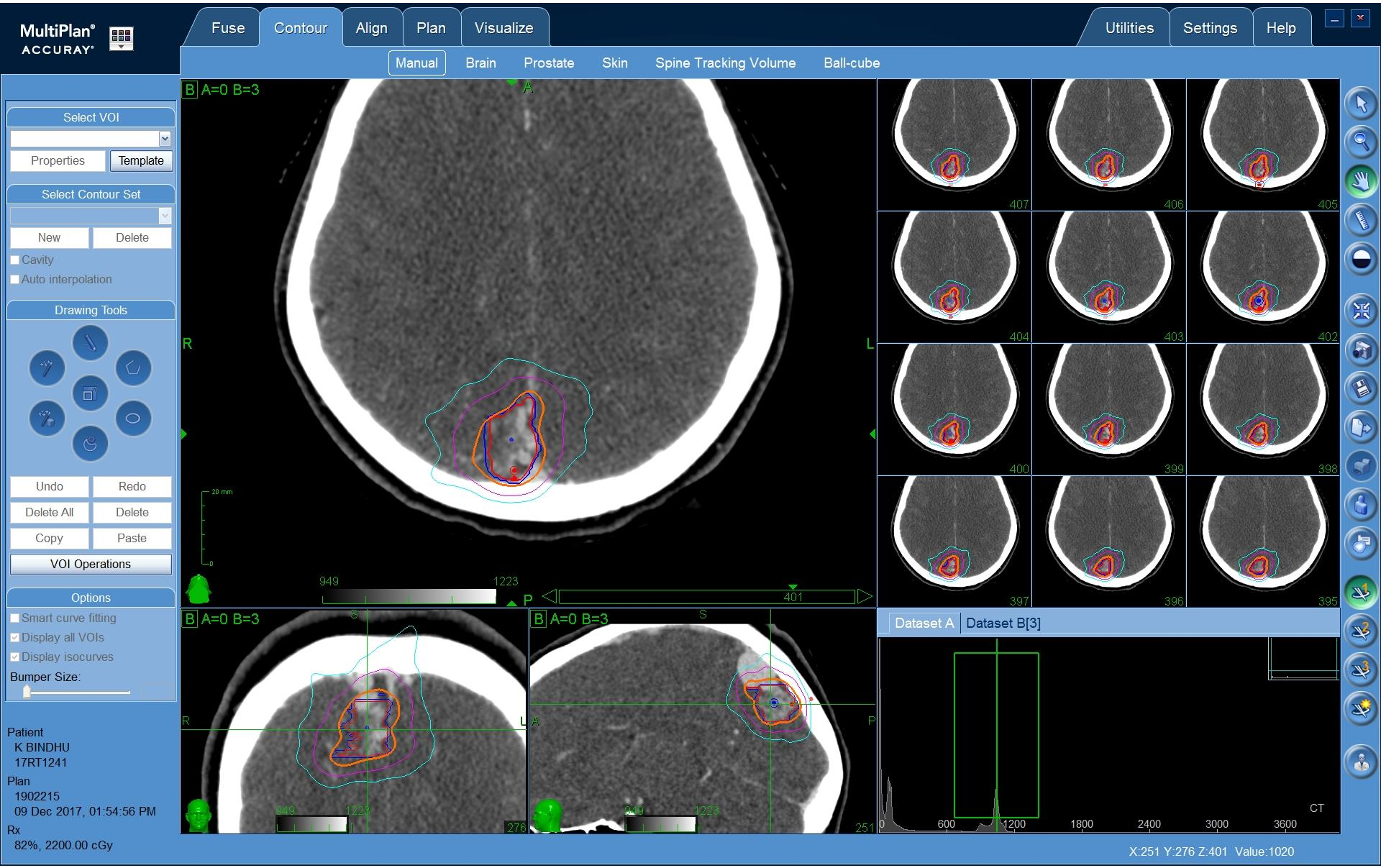
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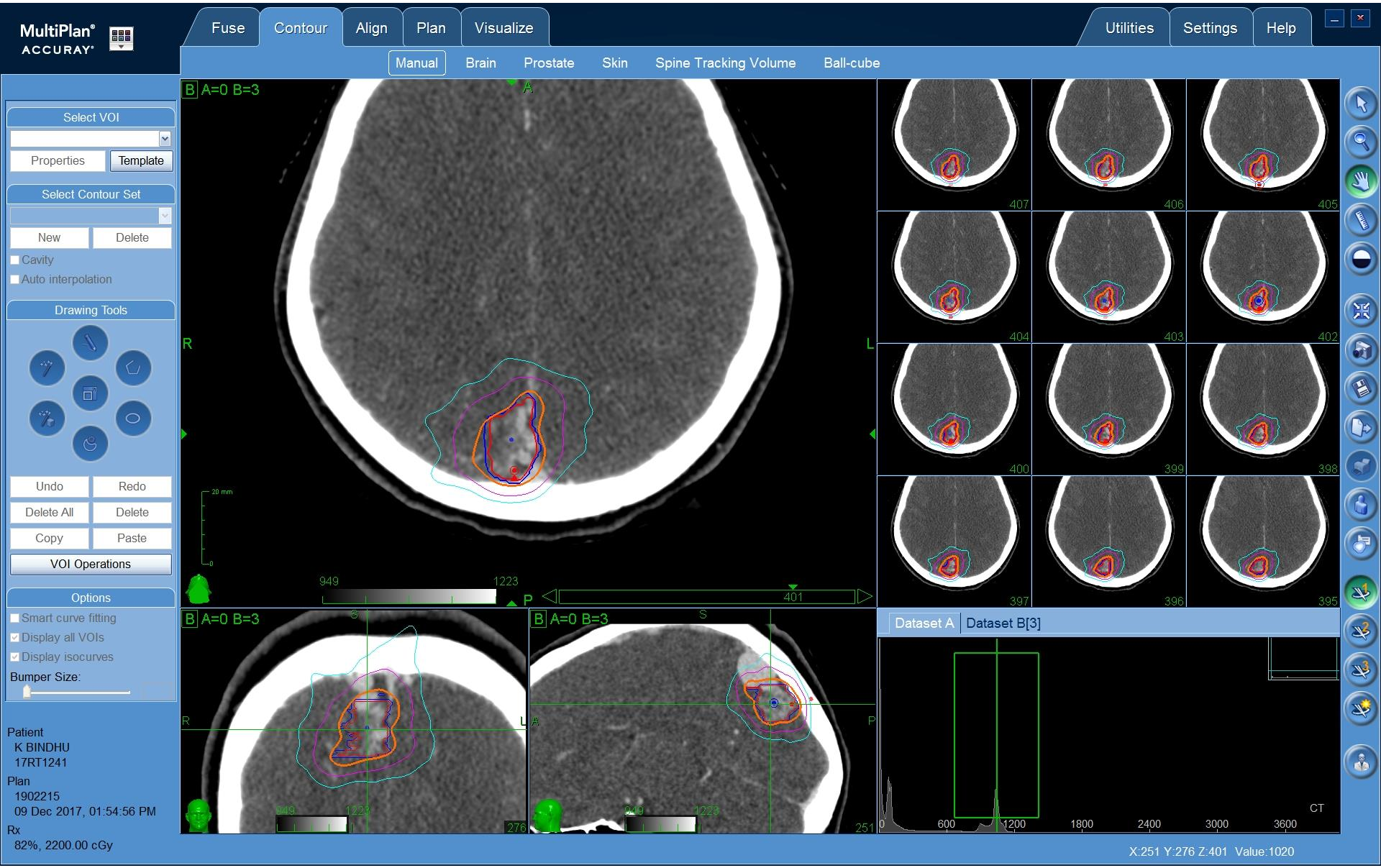
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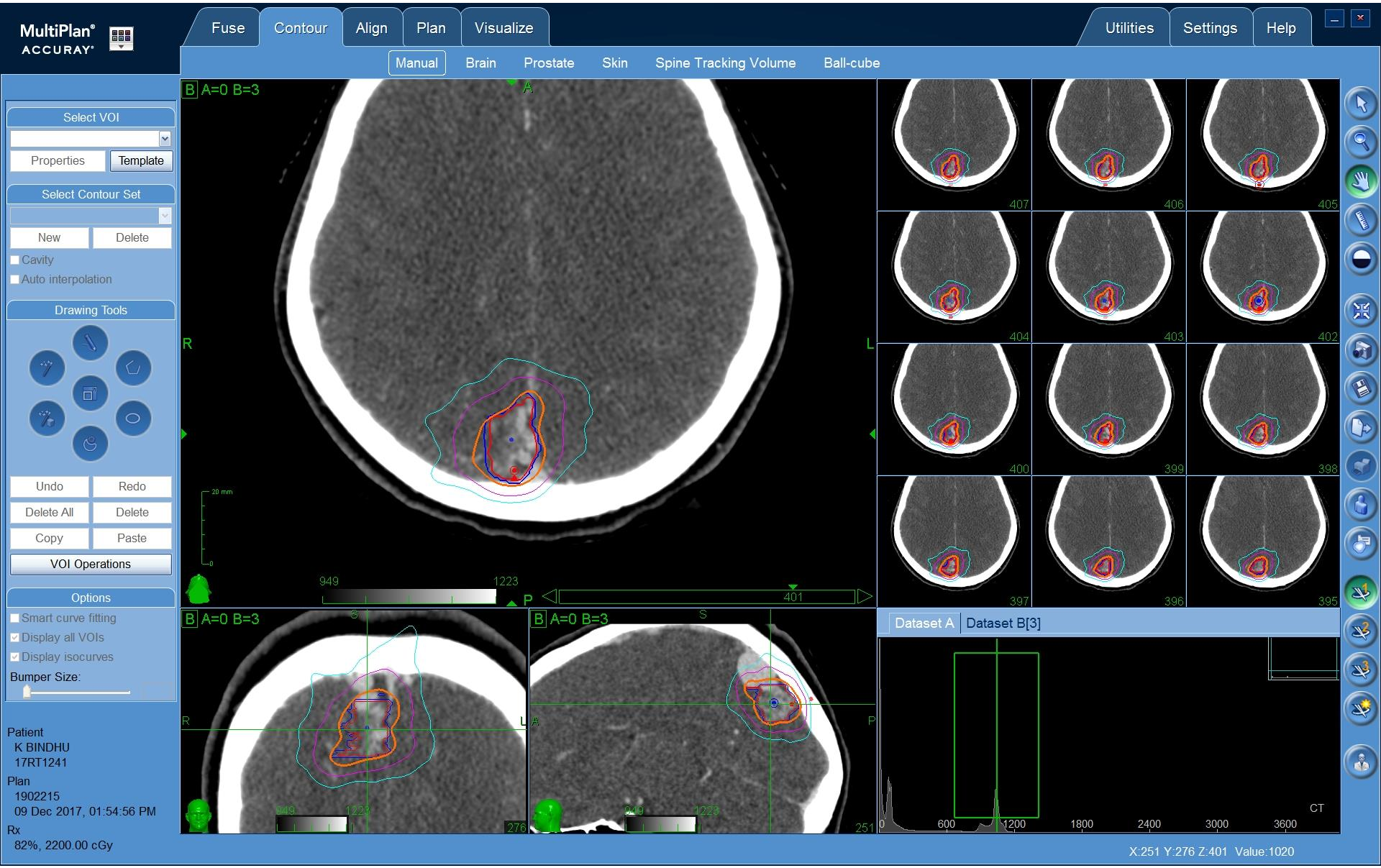
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Manual
Brain
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Skin
Spine Tracking Volume
Ball-cube
Select VOI
Properties
Template
Select Contour Set
New
Delete
Cavity
Auto interpolation
Drawing Tools
Undo
Redo
Delete All
Delete
Copy
Paste
VOI Operations
Options
Smart curve fitting
Display all VOIs
Display isocurves
Bumper Size:
Patient
K BINDHU
17RT1241
Plan
1902215
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Rx
82%, 2200.00 cGy
B A=0 B=3
949
1223
401
276
251
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Dataset B[3]
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600
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1800
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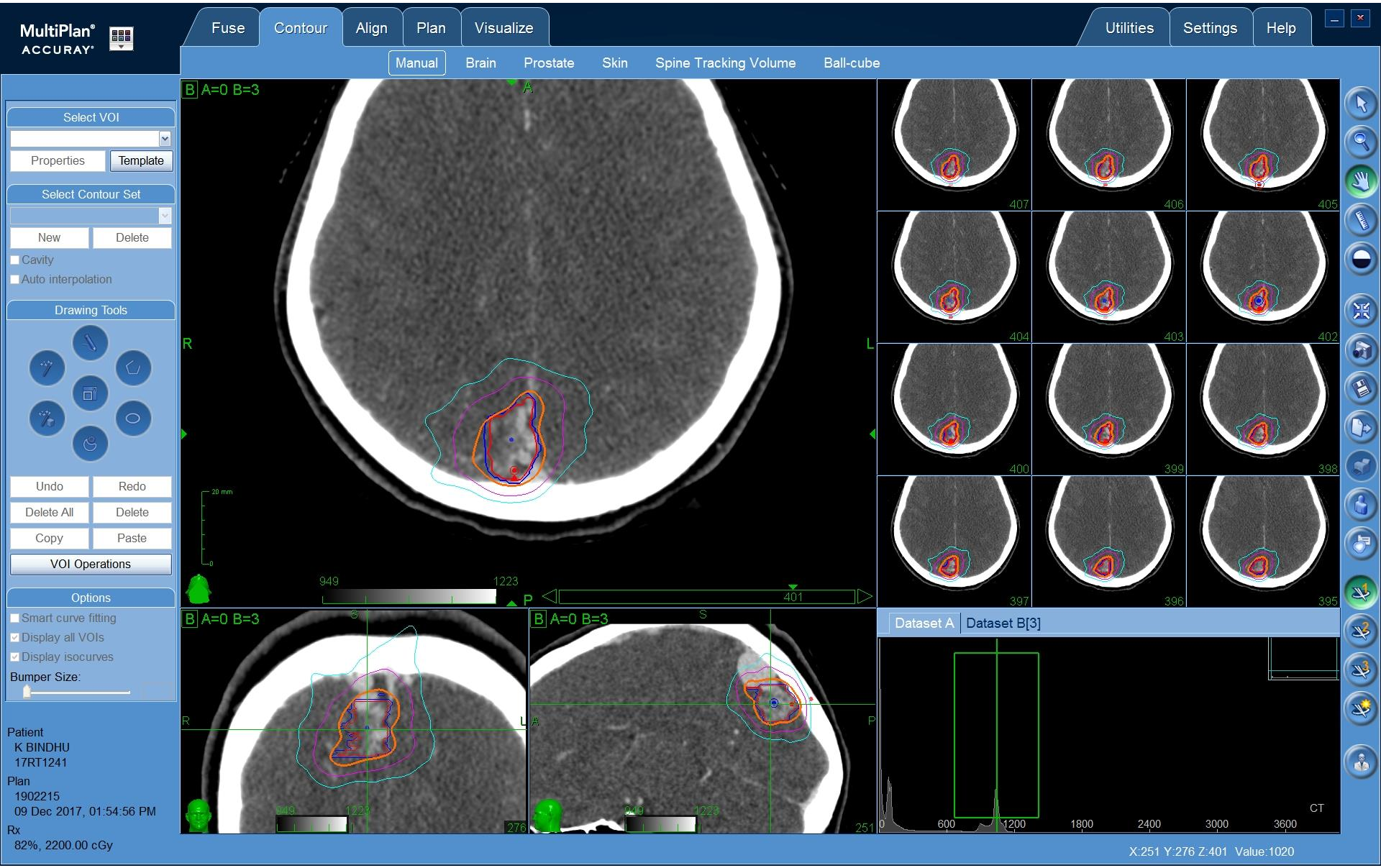
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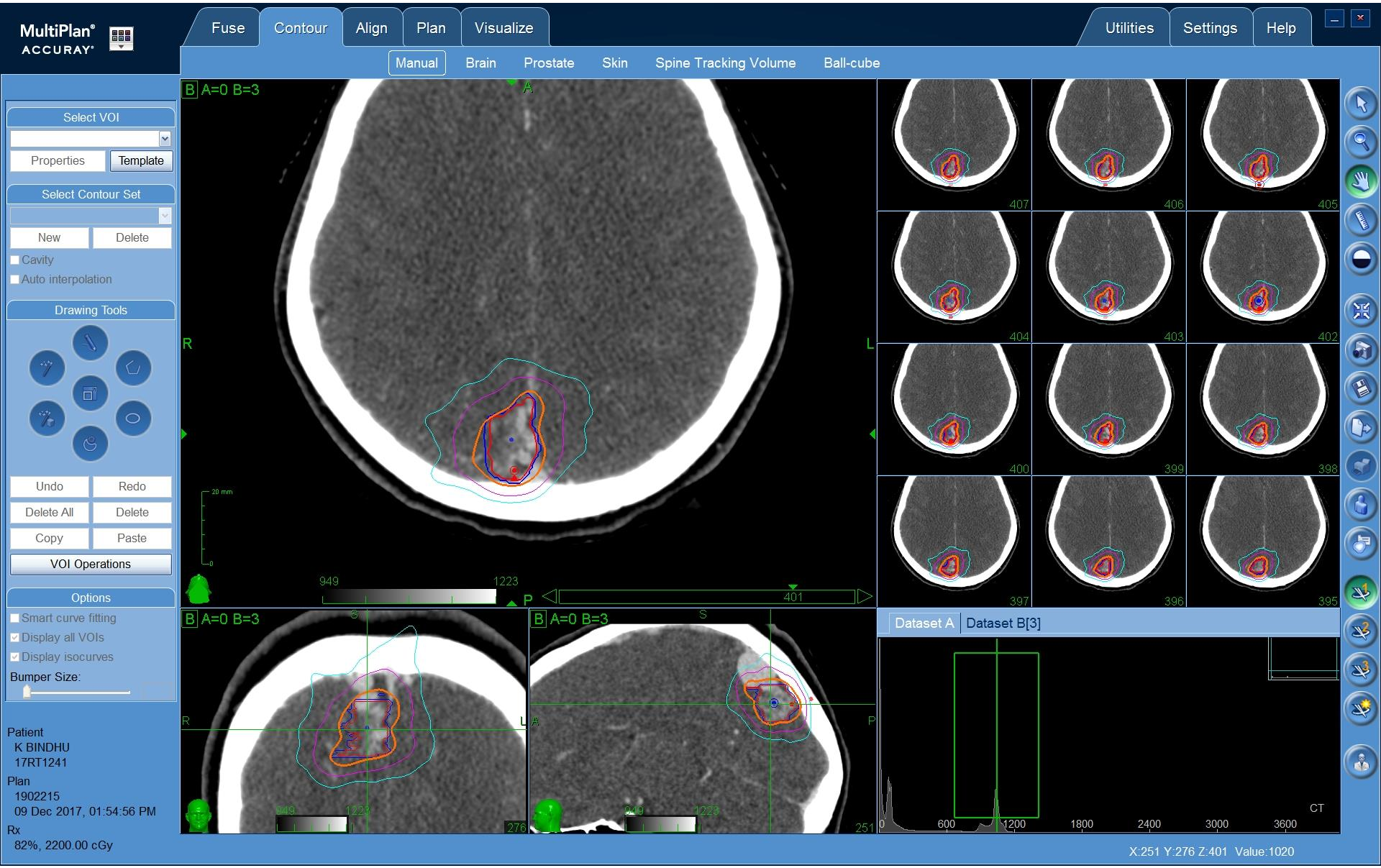
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1200
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2400
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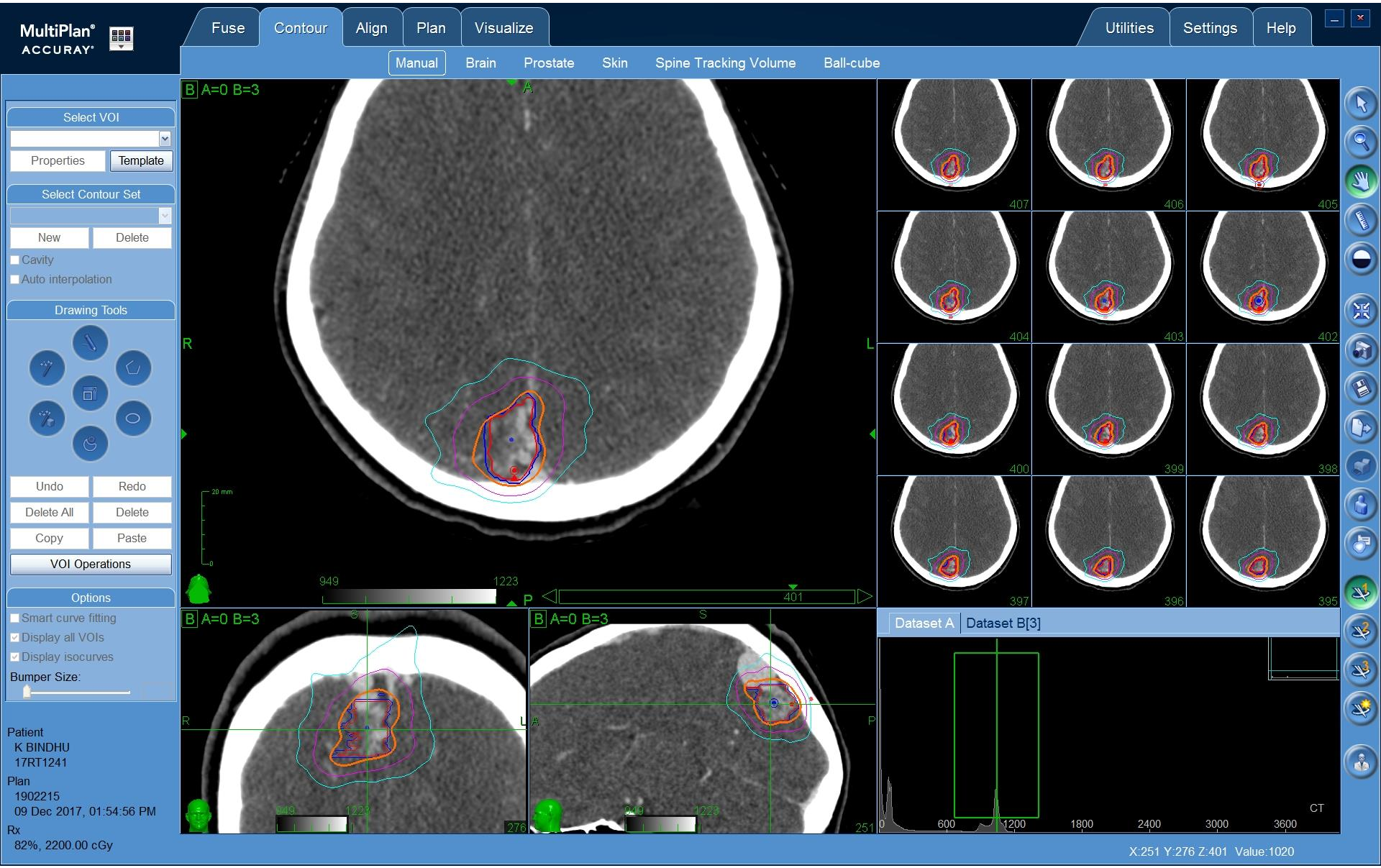
X:251 Y:276 Z:401 Value:1020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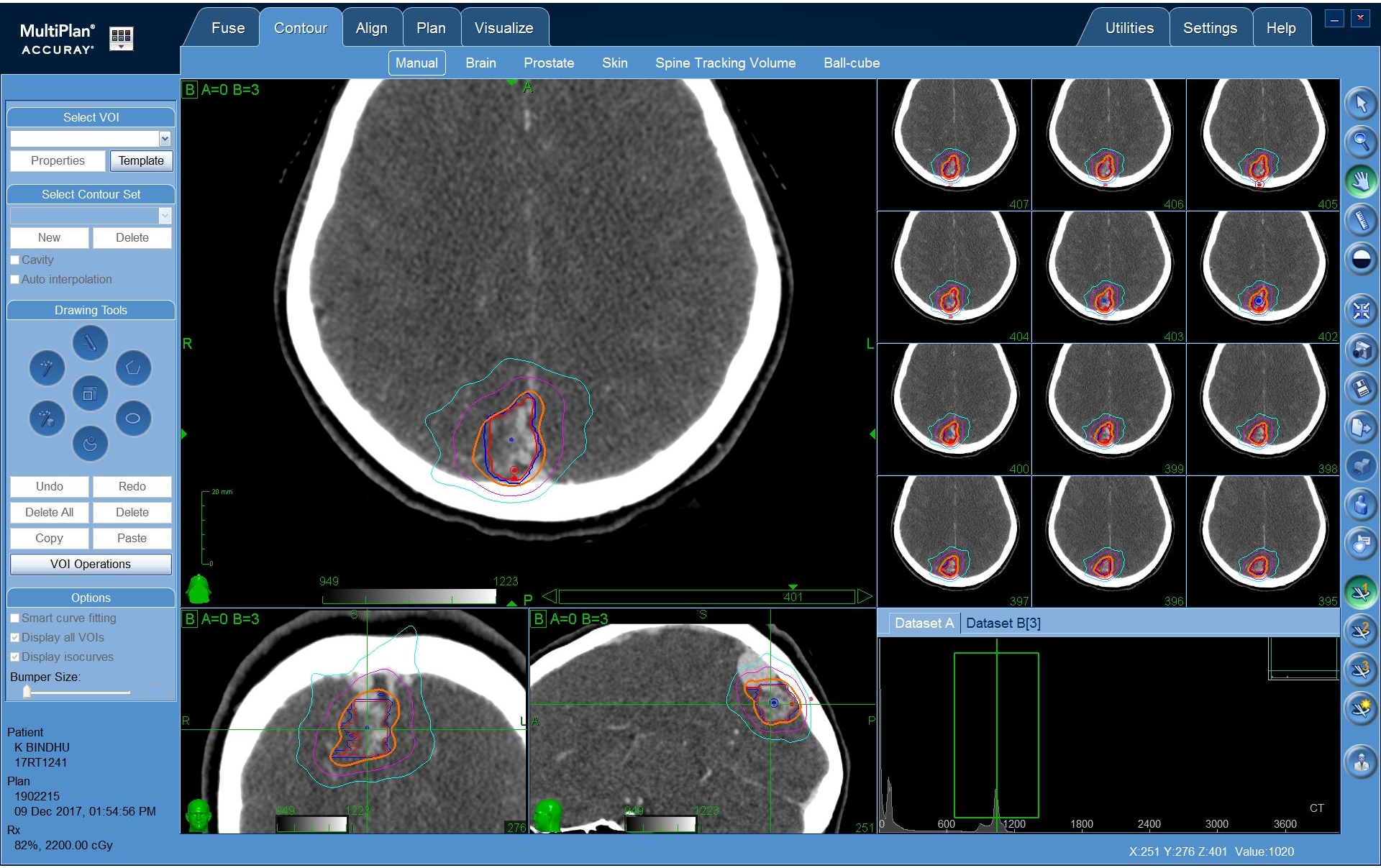
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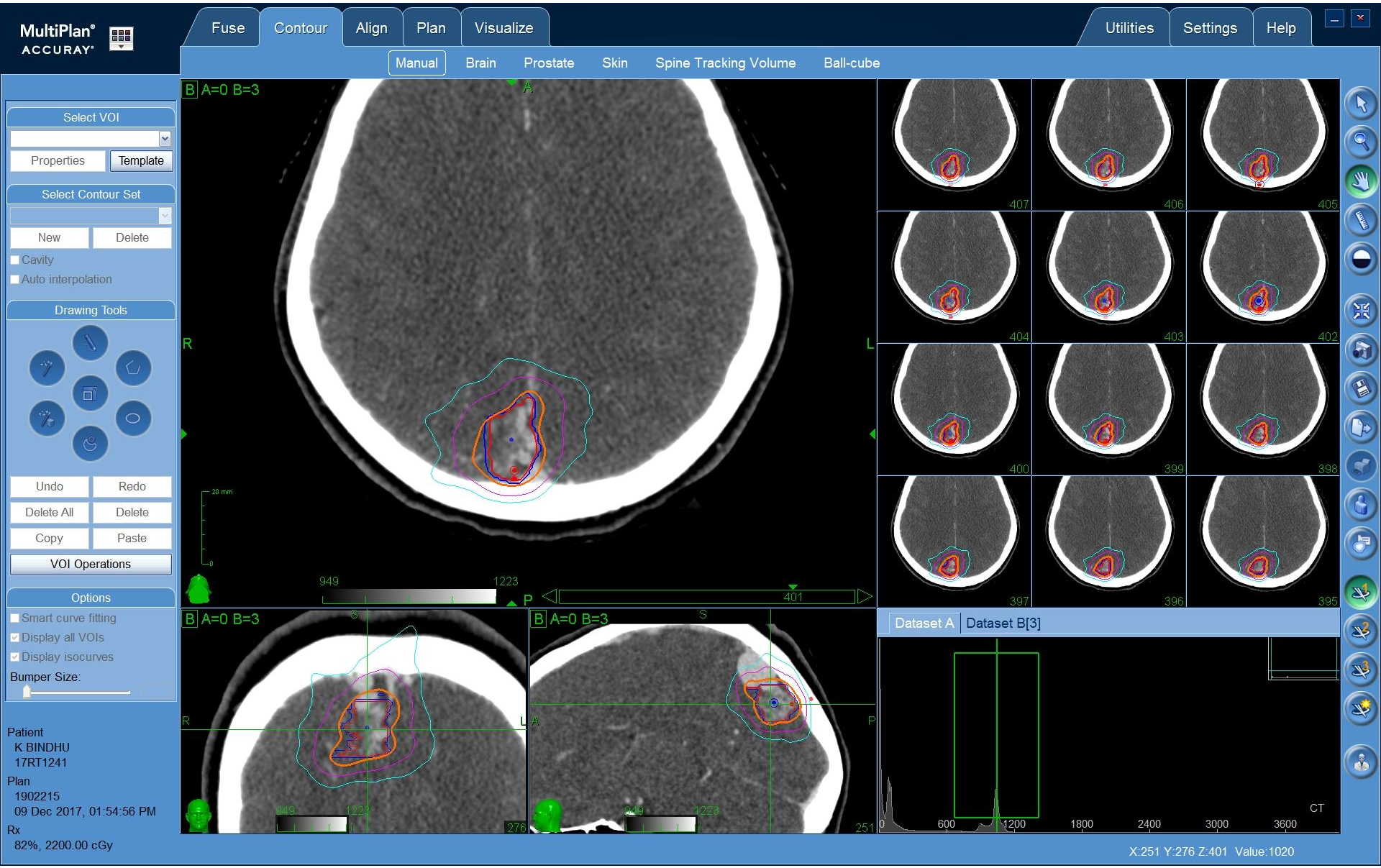
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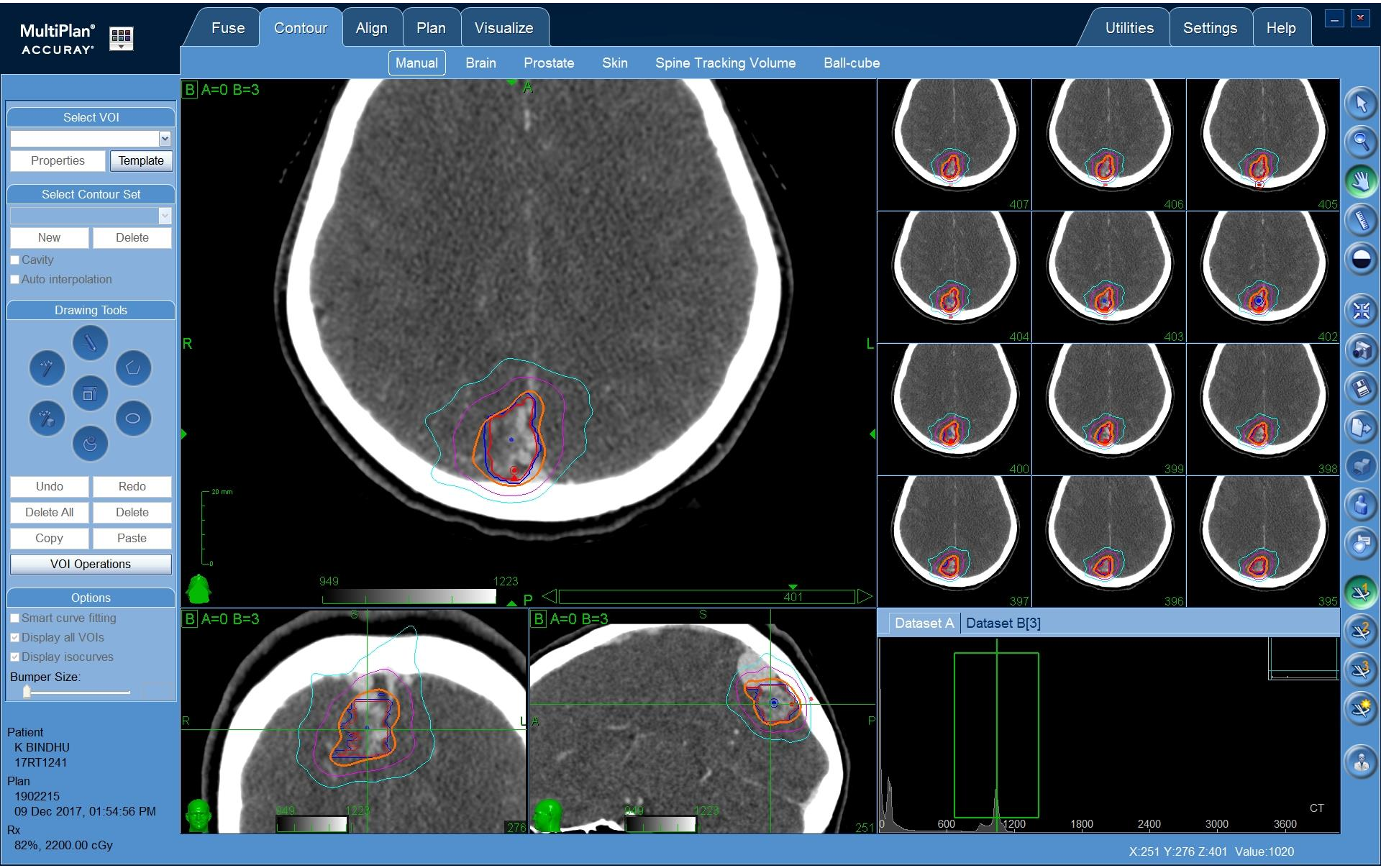
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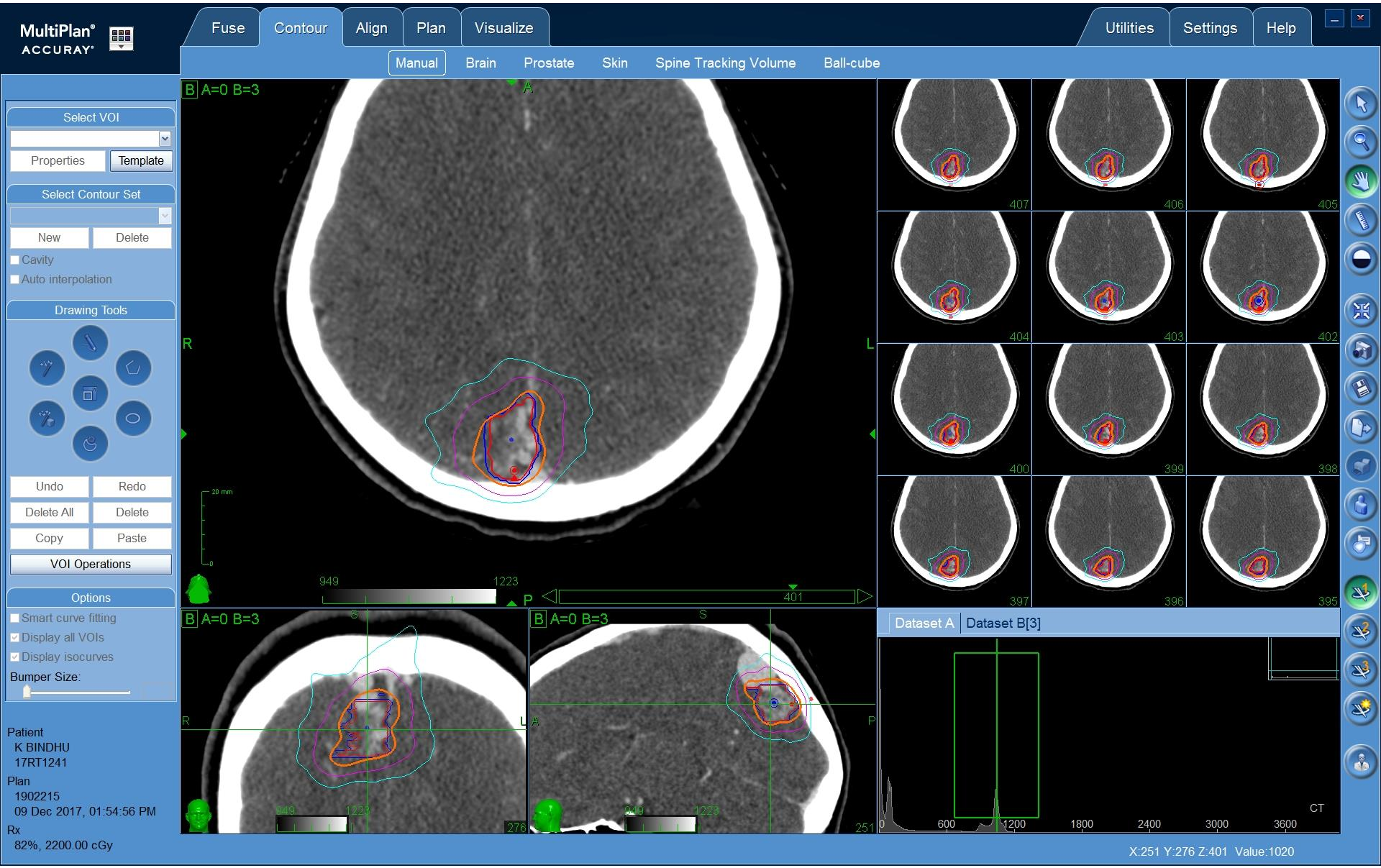
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82%, 2200.00 cGy
B A=0 B=3
949
1223
401
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Dataset A
Dataset B[3]
CT
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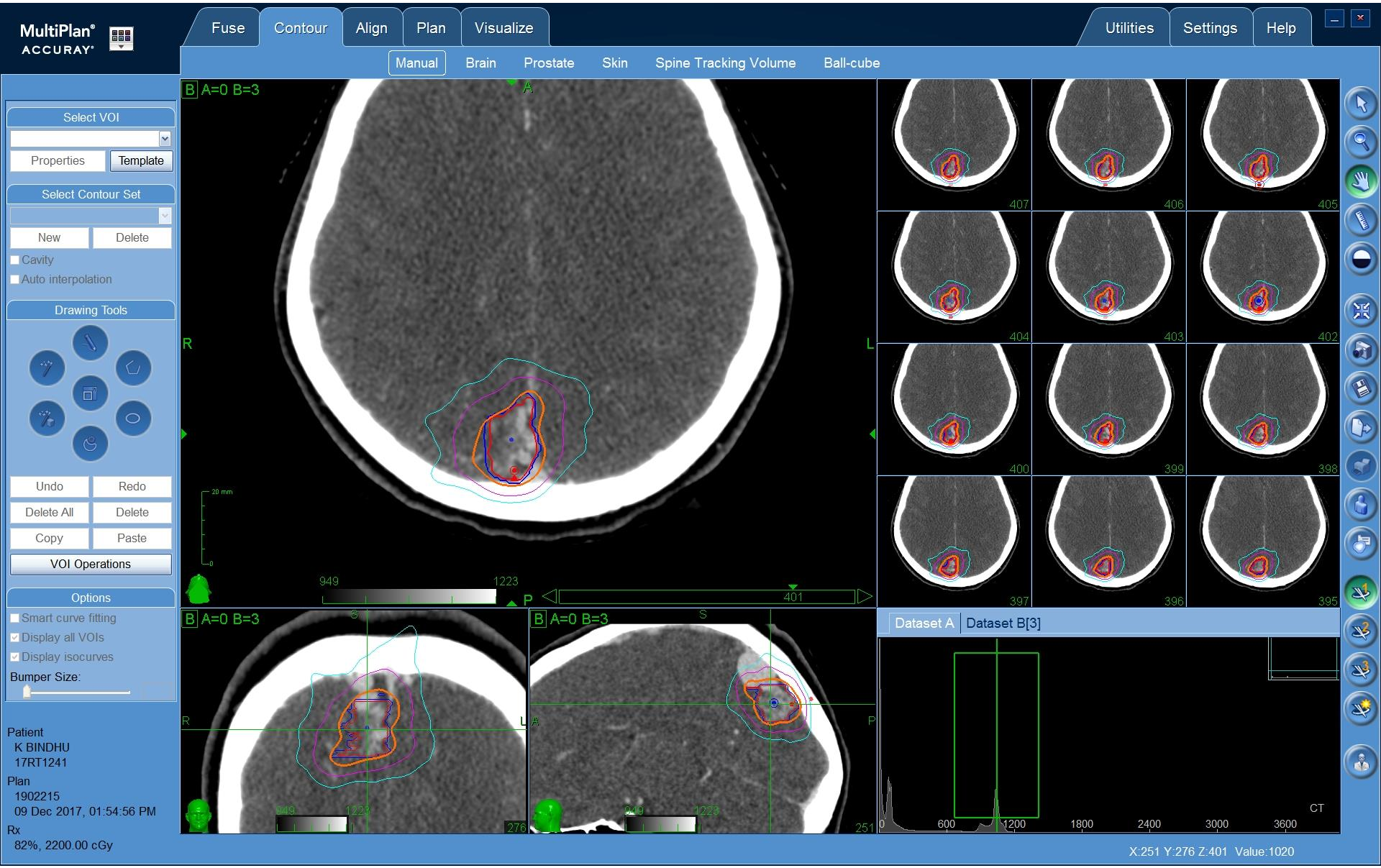
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Template
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New
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Patient
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Rx
82%, 2200.00 cGy
B A=0 B=3
949
1223
401
276
251
Dataset A
Dataset B[3]
CT
600
1200
1800
2400
3000
3600
X:251 Y:276 Z:401 Value:1020


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Isocentric
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Sequential
Evaluate
Finetune
Dose Calculation
Algorithm
Ray-Tracing
Resolution
High
Calculate
Prescription
Prescription
Reference Point
Use max dose point
Dose (cGy)
2682.93
Point
Go to >>
-3.10,-0.51,43.00
Set to Cross-hair Point
Save Plan
Save Plan
Standard
Display
Patient
K BINDHU
17RT1241
Plan
1902215
09 Dec 2017, 01:54:56 PM
Rx
82%, 2200.00 cGy
A A=0 B=1
A A=0 B=1
Ray High (C)
82%
90%
70%
60%
40%
23%
Of 2682.93 cGy
A
R
L
P
100 mm
254
DVH Properties
Selected DVH:
Nidus
Volume(%)
Dose(%)
Nodes 77
Beams 120
Total MU 15088.1
Min MU 17.9
Max MU 149.0
Max Dose (cGy) 2682.93
Estimated Treatment Time Per Fraction (minutes) 42
Dose Statistics Table
Dx Vx Values
Plan Information
Name
Min (cGy)
Mean (cGy)
Max (cGy)
CI
nCI
HI
Coverage (%)
Nidus 2200.34 2487.95 2682.93 2.30 2.30 1.22 100.00
PTV 2115.60 2474.21 2682.93 1.64 1.65 1.22 99.90
Left Eye 1.72 2.14 22.68 n/a n/a n/a n/a
*Right Eye
Brain Stem 3.44 5.71 61.86 n/a n/a n/a n/a
Brain 1.15 124.57 2682.93 n/a n/a n/a n/a
LENS RIGHT 1.80 1.85 2.13 0.00 0.00 1.22 0.00
LENS LEFT 1.80 1.83 2.01 0.00 0.00 1.22 0.00
ON RIGHT 2.33 28.03 124.70 0.00 0.00 1.22 0.00
LT NR 2.37 2.93 4.26 0.00 0.00 1.22 0.00
SKIN 12.16 211.83 648.63 n/a n/a n/a n/a


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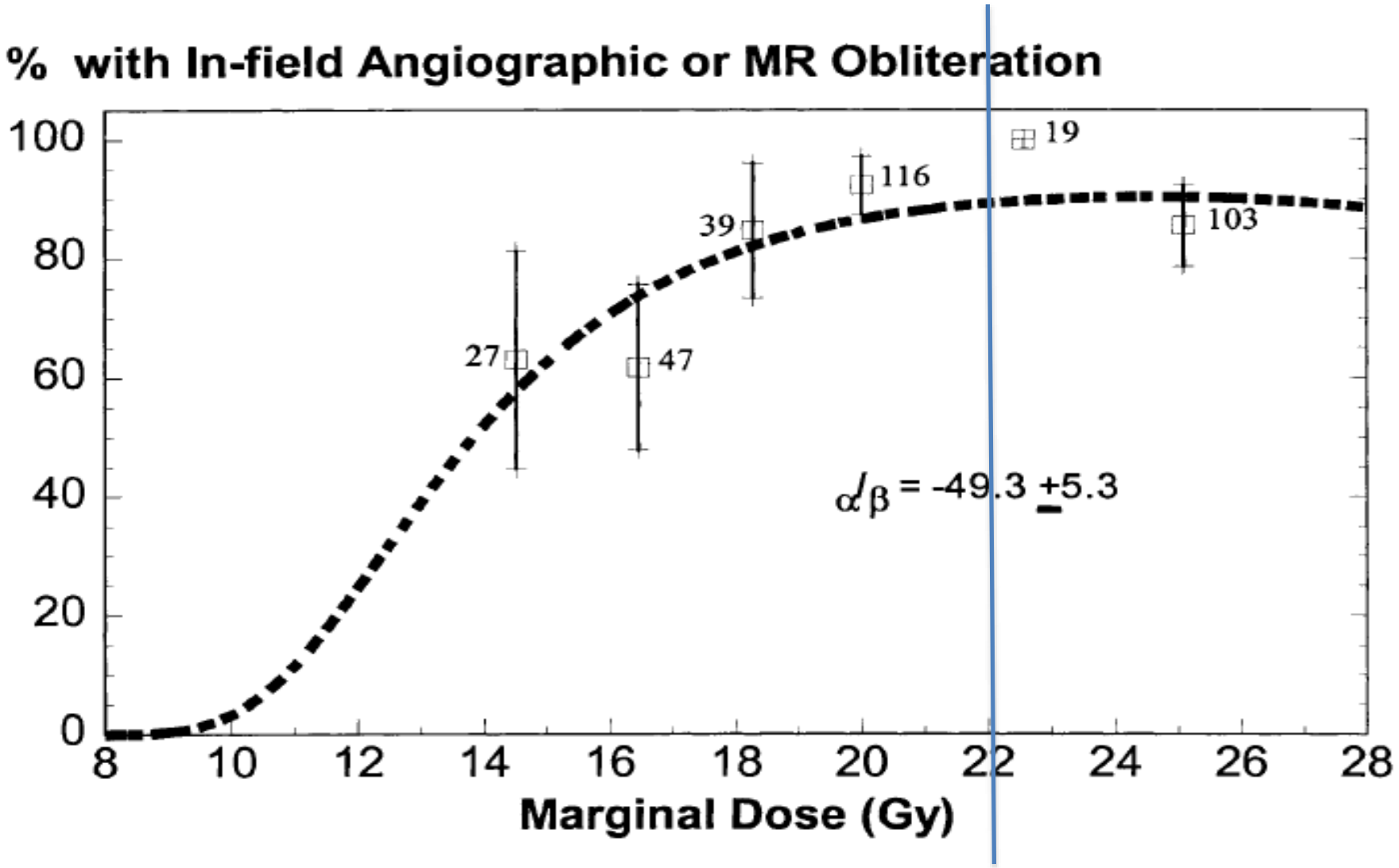
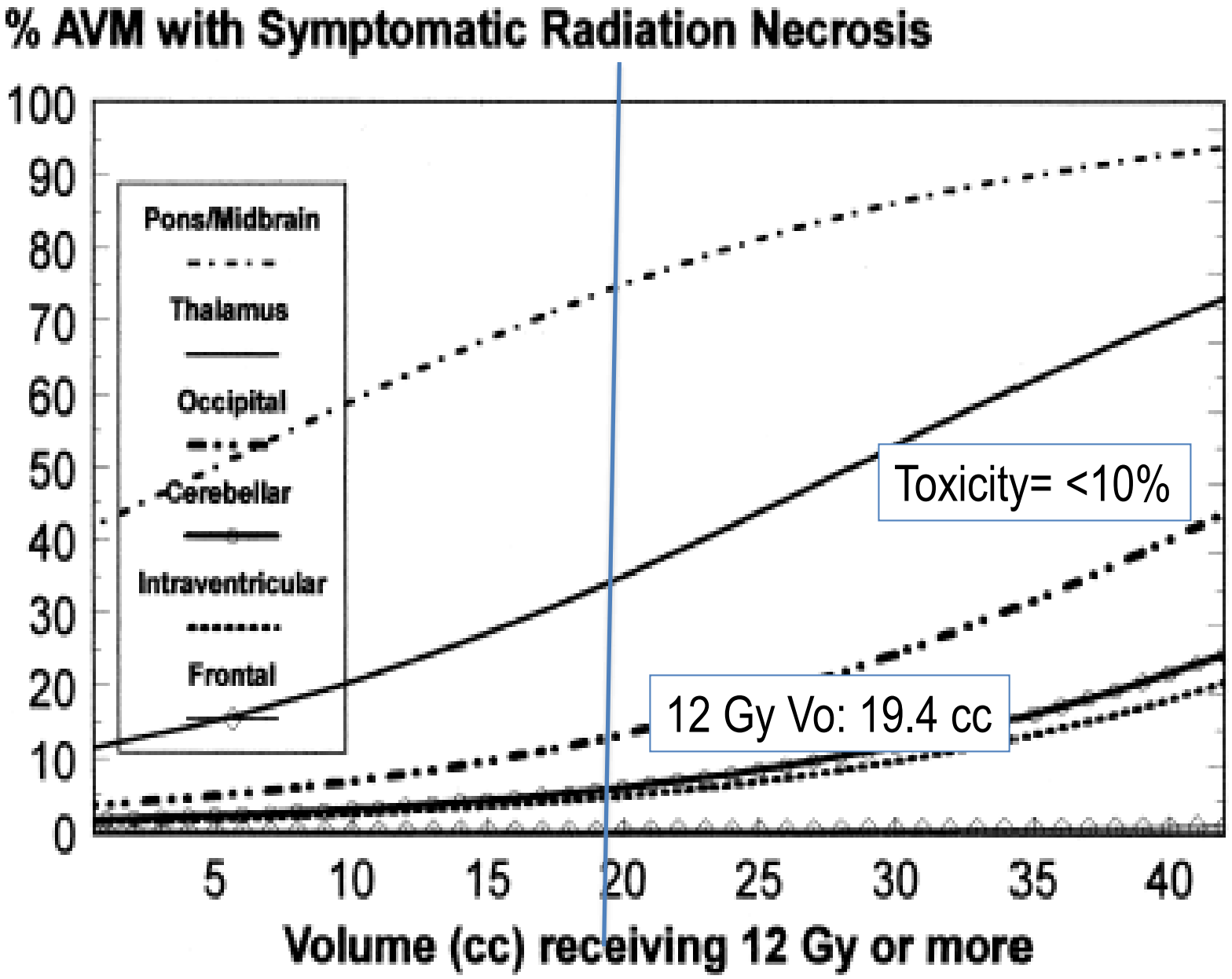
Sequential
Evaluate
Finetune
Dose Calculation
Algorithm
Ray-Tracing
Resolution
High
Calculate
Prescription
Prescription
Reference Point
Use max dose point
Dose (cGy)
2682.93
Point
Go to >>
-3.10,-0.51,43.00
Set to Cross-hair Point
Save Plan
Save Plan
Standard
Display
Patient
K BINDHU
17RT1241
Plan
1902215
09 Dec 2017, 01:54:56 PM
Rx
82%, 2200.00 cGy
A A=0 B=1
A A=0 B=1
Ray High (C)
82%
90%
70%
60%
40%
23%
Of 2682.93 cGy
A
R
L
P
100 mm
254
DVH Properties
Selected DVH:
Nidus
Volume(%)
Dose(%)
Nodes 77
Beams 120
Total MU 15088.1
Min MU 17.9
Max MU 149.0
Max Dose (cGy) 2682.93
Estimated Treatment Time Per Fraction (minutes) 42
Dose Statistics Table
Dx Vx Values
Plan Information
Name
Min (cGy)
Mean (cGy)
Max (cGy)
CI
nCI
HI
Coverage (%)
Nidus 2200.34 2487.95 2682.93 2.30 2.30 1.22 100.00
PTV 2115.60 2474.21 2682.93 1.64 1.65 1.22 99.90
Left Eye 1.72 2.14 22.68 n/a n/a n/a n/a
*Right Eye
Brain Stem 3.44 5.71 61.86 n/a n/a n/a n/a
Brain 1.15 124.57 2682.93 n/a n/a n/a n/a
LENS RIGHT 1.80 1.85 2.13 0.00 0.00 1.22 0.00
LENS LEFT 1.80 1.83 2.01 0.00 0.00 1.22 0.00
ON RIGHT 2.33 28.03 124.70 0.00 0.00 1.22 0.00
LT NR 2.37 2.93 4.26 0.00 0.00 1.22 0.00
SKIN 12.16 211.83 648.63 n/a n/a n/a n/a

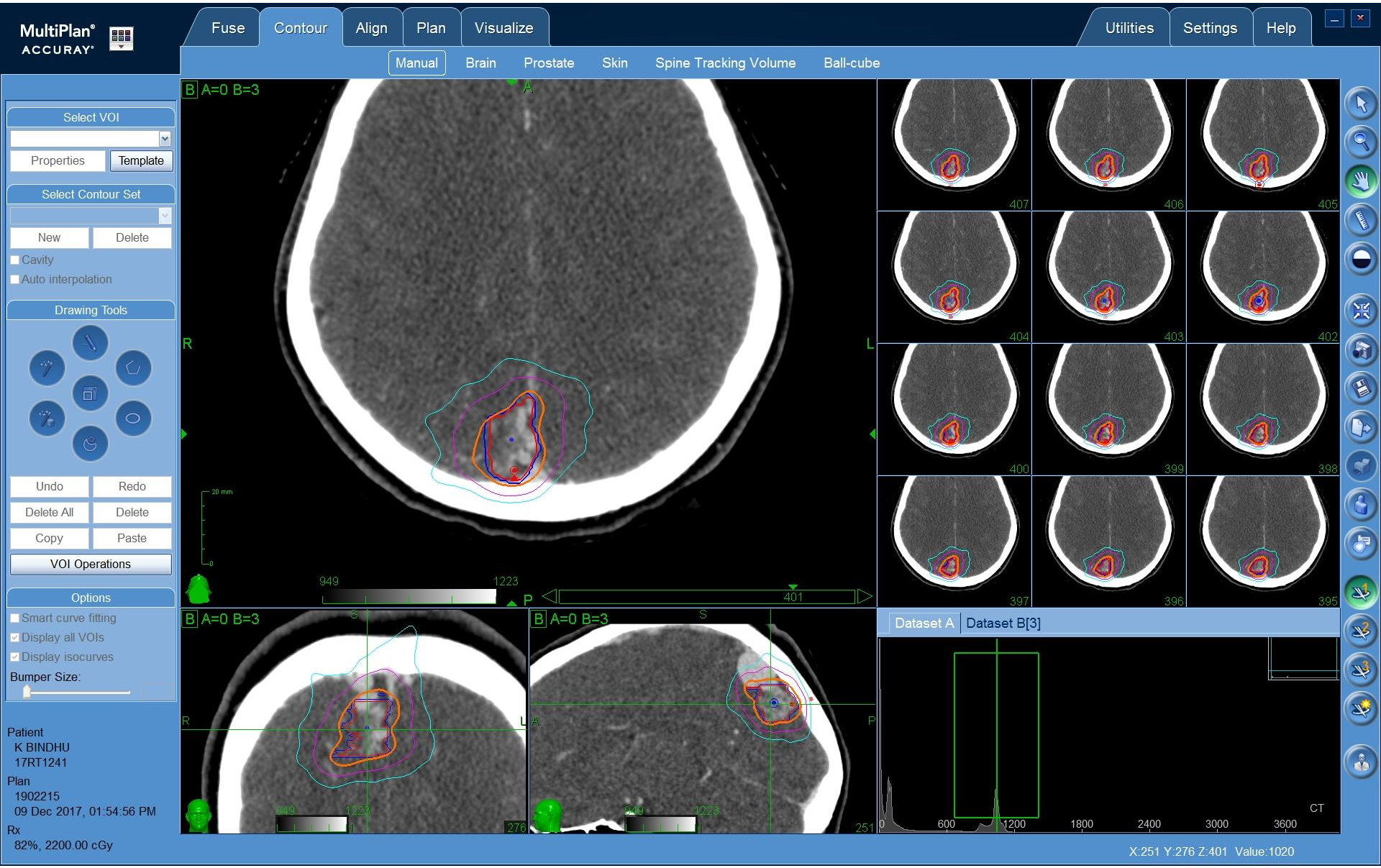


Obliteration rate = 85%

Long-term Toxicity



Case 2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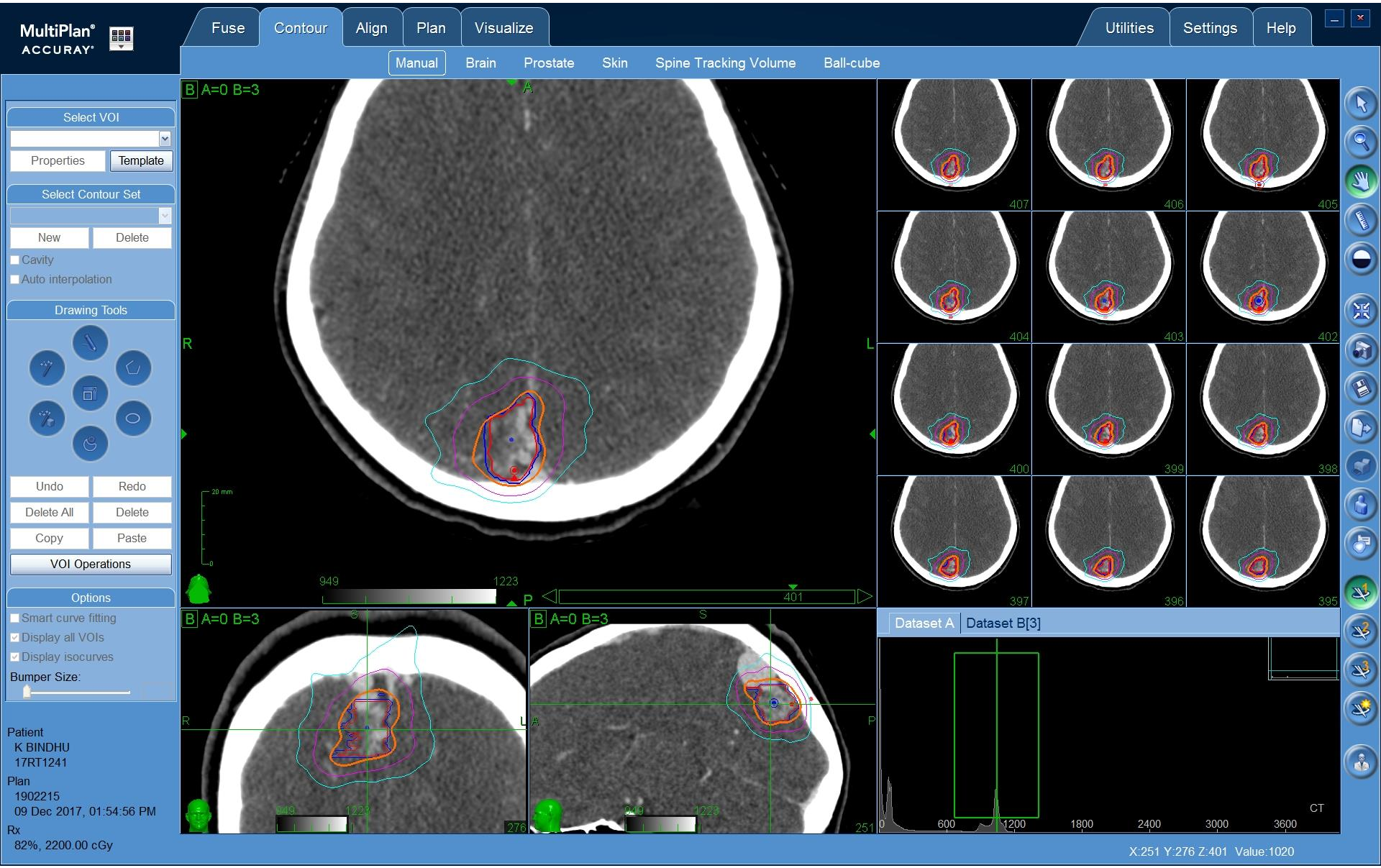
Manual
Brain
Prostate
Skin
Spine Tracking Volume
Ball-cube
Select VOI
Properties
Template
Select Contour Set
New
Delete
Cavity
Auto interpolation
Drawing Tools
Undo
Redo
Delete All
Delete
Copy
Paste
VOI Operations
Options
Smart curve fitting
Display all VOIs
Display isocurves
Bumper Size:
Patient
K BINDHU
17RT1241
Plan
1902215
09 Dec 2017, 01:54:56 PM
Rx
82%, 2200.00 cGy
B A=0 B=3
949
1223
401
276
251
Dataset A
Dataset B[3]
CT
600
1200
1800
2400
3000
3600
X:251 Y:276 Z:401 Value:1020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Patient
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17RT1241
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1902215
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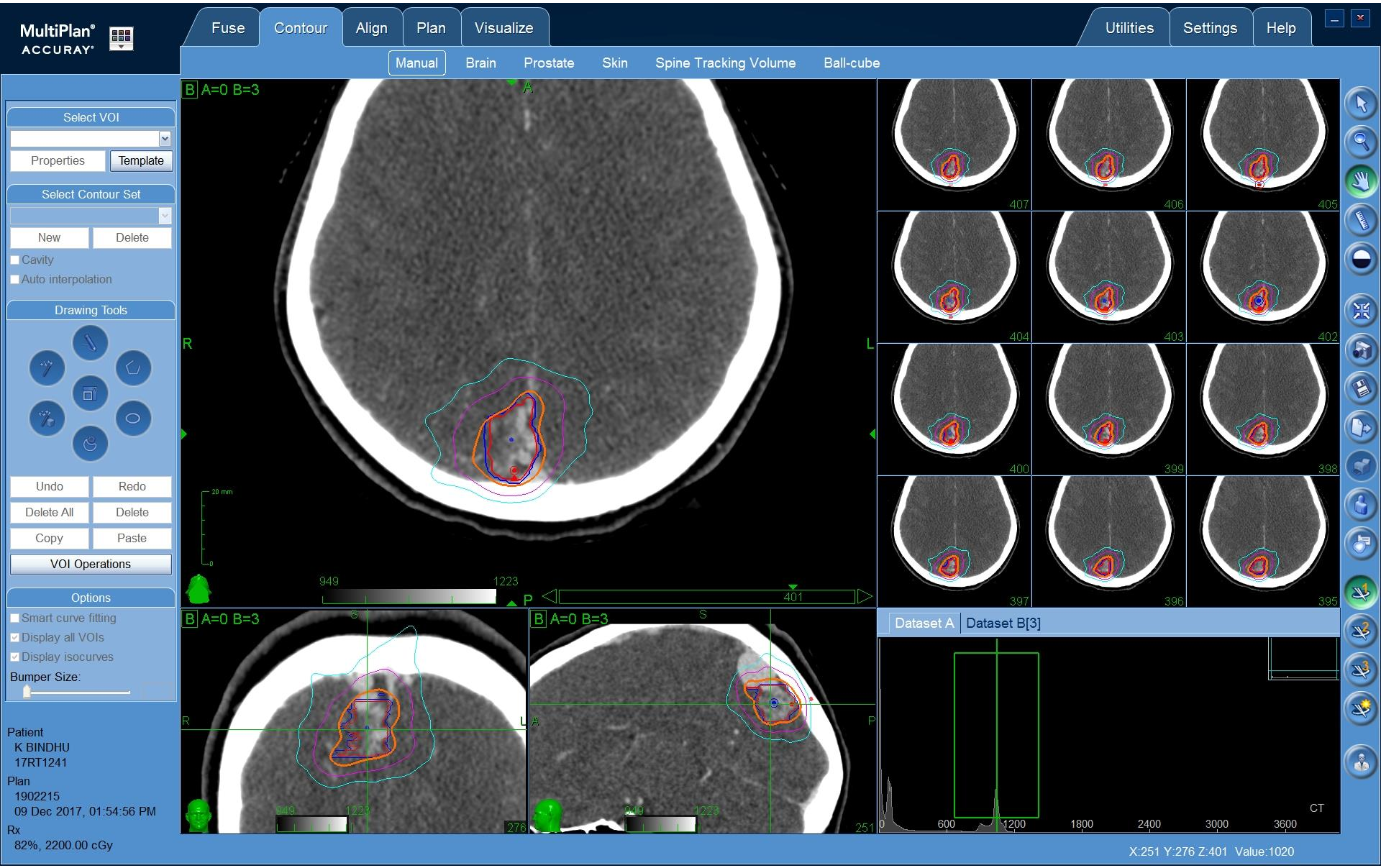
82%, 2200.00 cGy
B A=0 B=3
949
1223
401
276
251
Dataset A
Dataset B[3]
CT
600
1200
1800
2400
3000
3600
X:251 Y:276 Z:401 Value:1020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Prostate
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Ball-cube
Select VOI
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Template
Select Contour Set
New
Delete
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949
1223
401
276
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Dataset A
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600
1200
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X:251 Y:276 Z:401 Value:1020


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Finetune
Dose Calculation
Algorithm
Ray-Tracing
Resolution
High
Calculate
Prescription
Prescription
Reference Point
Use max dose point
Dose (cGy)
2682.93
Point
Go to >>
-3.10,-0.51,43.00
Set to Cross-hair Point
Save Plan
Save Plan
Standard
Display
Patient
K BINDHU
17RT1241
Plan
1902215
09 Dec 2017, 01:54:56 PM
Rx
82%, 2200.00 cGy
A A=0 B=1
A A=0 B=1
Ray High (C)
82%
90%
70%
60%
40%
23%
Of 2682.93 cGy
A
R
L
P
100 mm
254
DVH Properties
Selected DVH:
Nidus
Volume(%)
Dose(%)
Nodes 77
Beams 120
Total MU 15088.1
Min MU 17.9
Max MU 149.0
Max Dose (cGy) 2682.93
Estimated Treatment Time Per Fraction (minutes) 42
Dose Statistics Table
Dx Vx Values
Plan Information
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Min (cGy)
Mean (cGy)
Max (cGy)
CI
nCI
HI
Coverage (%)
Nidus 2200.34 2487.95 2682.93 2.30 2.30 1.22 100.00
PTV 2115.60 2474.21 2682.93 1.64 1.65 1.22 99.90
Left Eye 1.72 2.14 22.68 n/a n/a n/a n/a
*Right Eye
Brain Stem 3.44 5.71 61.86 n/a n/a n/a n/a
Brain 1.15 124.57 2682.93 n/a n/a n/a n/a
LENS RIGHT 1.80 1.85 2.13 0.00 0.00 1.22 0.00
LENS LEFT 1.80 1.83 2.01 0.00 0.00 1.22 0.00
ON RIGHT 2.33 28.03 124.70 0.00 0.00 1.22 0.00
LT NR 2.37 2.93 4.26 0.00 0.00 1.22 0.00
SKIN 12.16 211.83 648.63 n/a n/a n/a n/a


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Prescription
Prescription
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-3.10,-0.51,43.00
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Save Plan
Save Plan
Standard
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Patient
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82%, 2200.00 cGy
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A A=0 B=1
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Brain 1.15 124.57 2682.93 n/a n/a n/a n/a
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ON RIGHT 2.33 28.03 124.70 0.00 0.00 1.22 0.00
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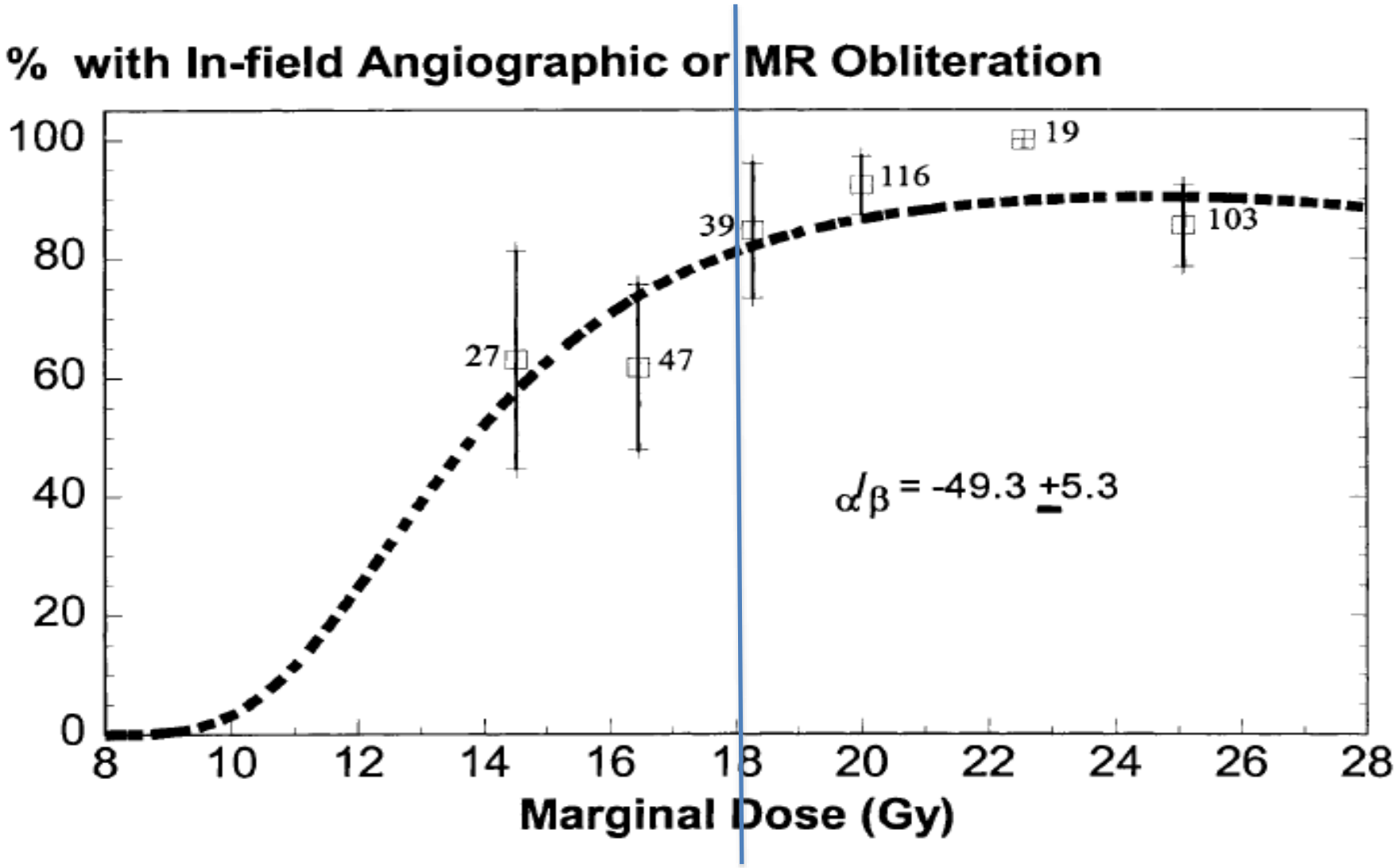
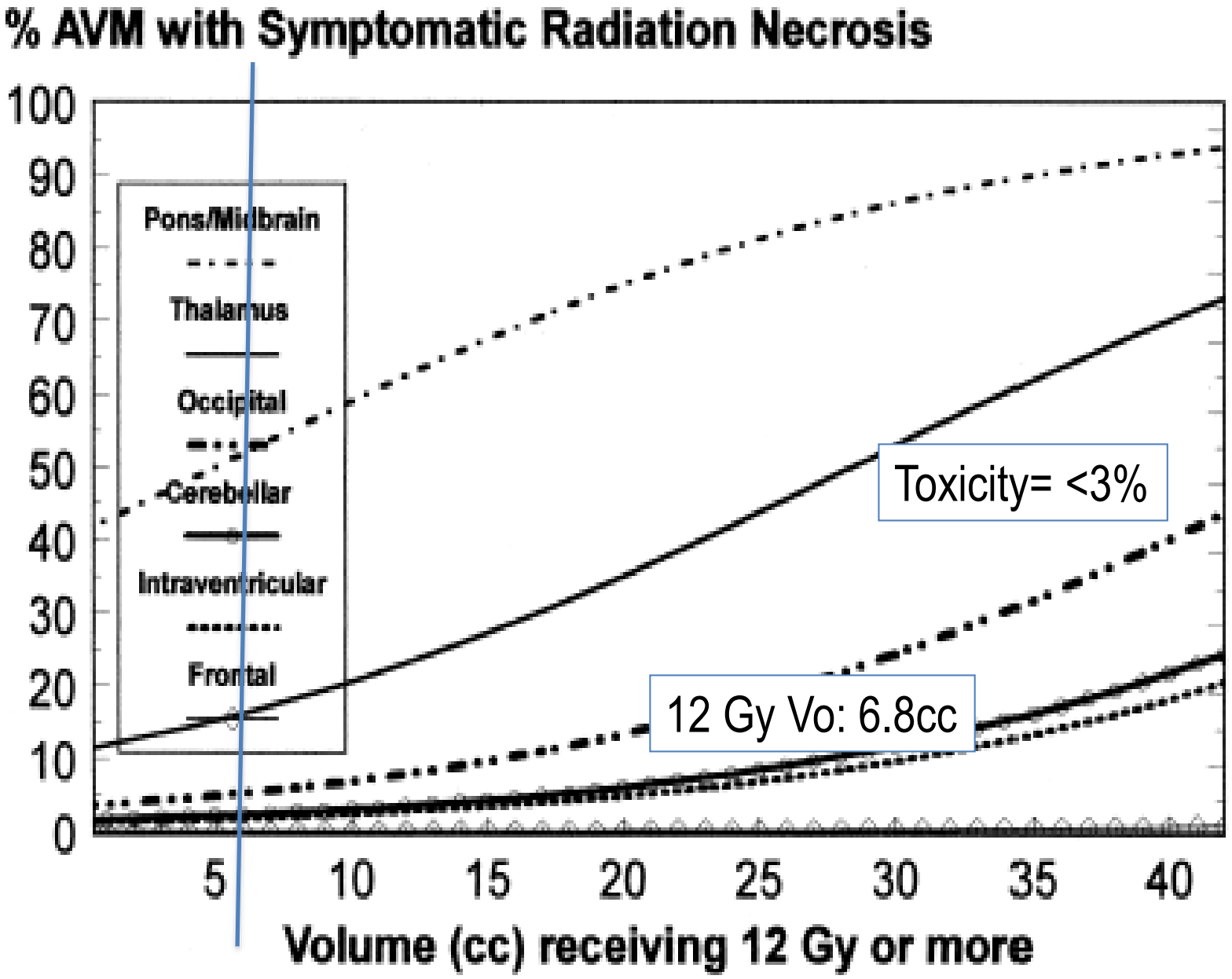
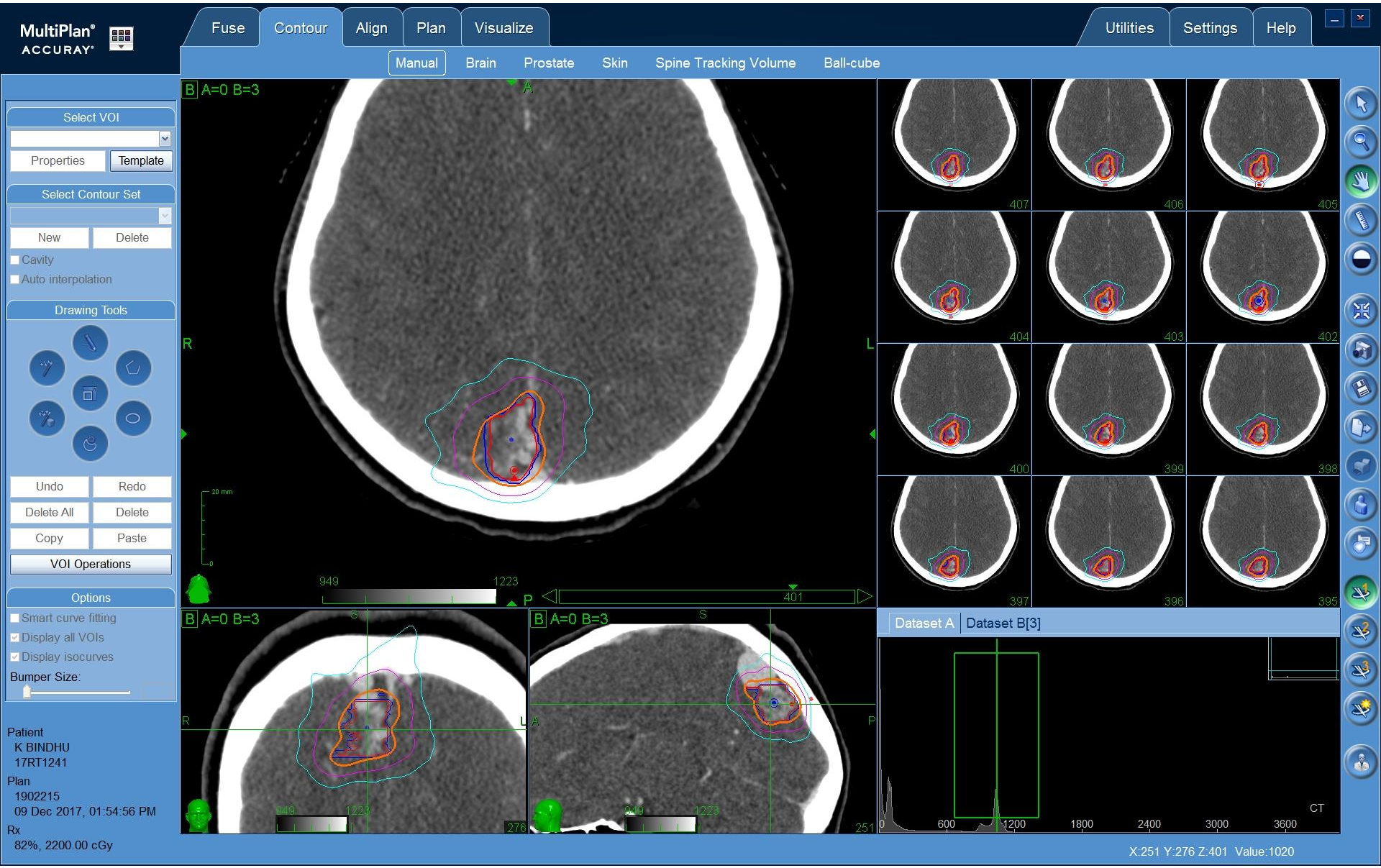


Obliteration rate = 80%

Long-term Toxicity



Case 3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Rx
82%, 2200.00 cGy
B A=0 B=3
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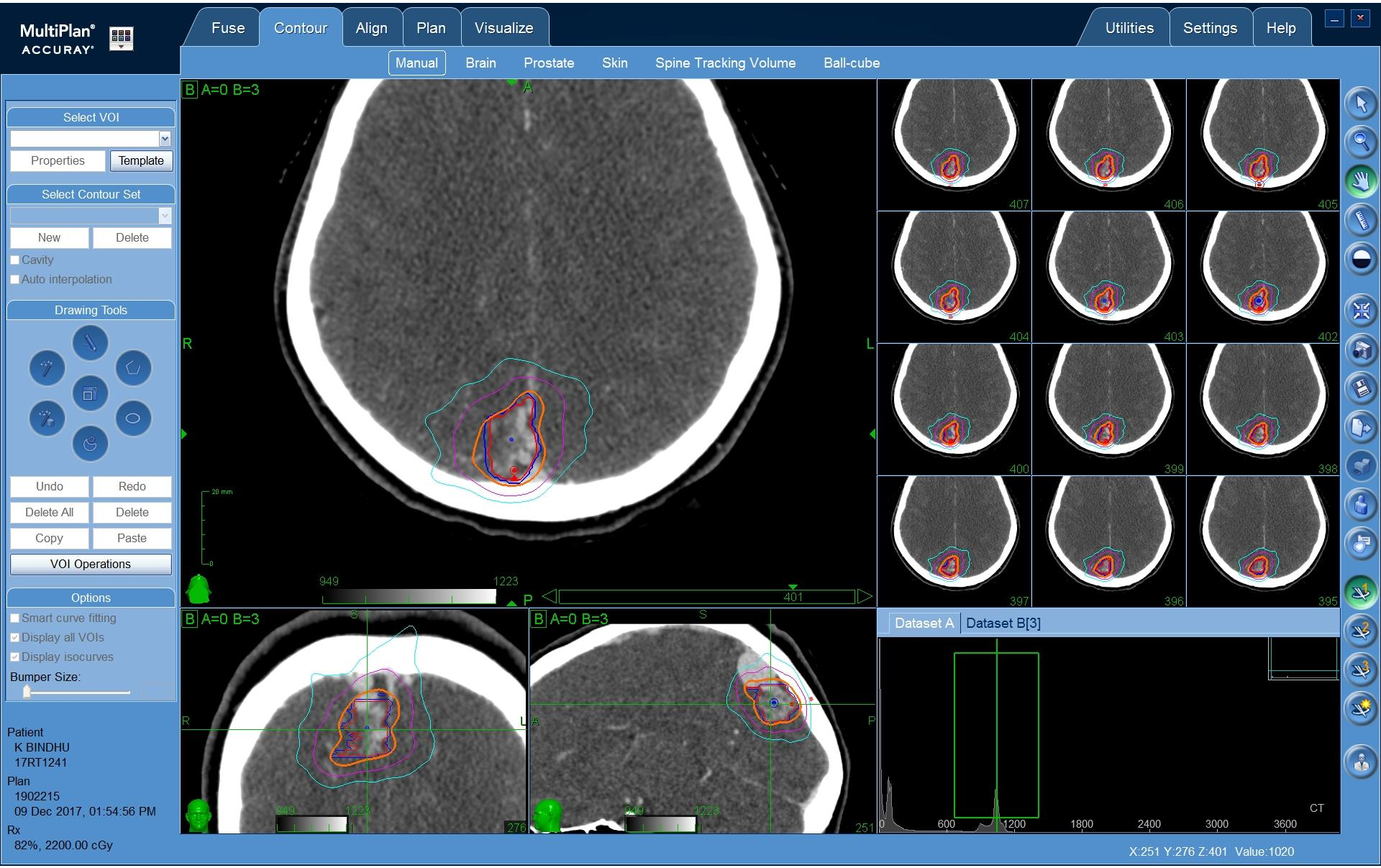
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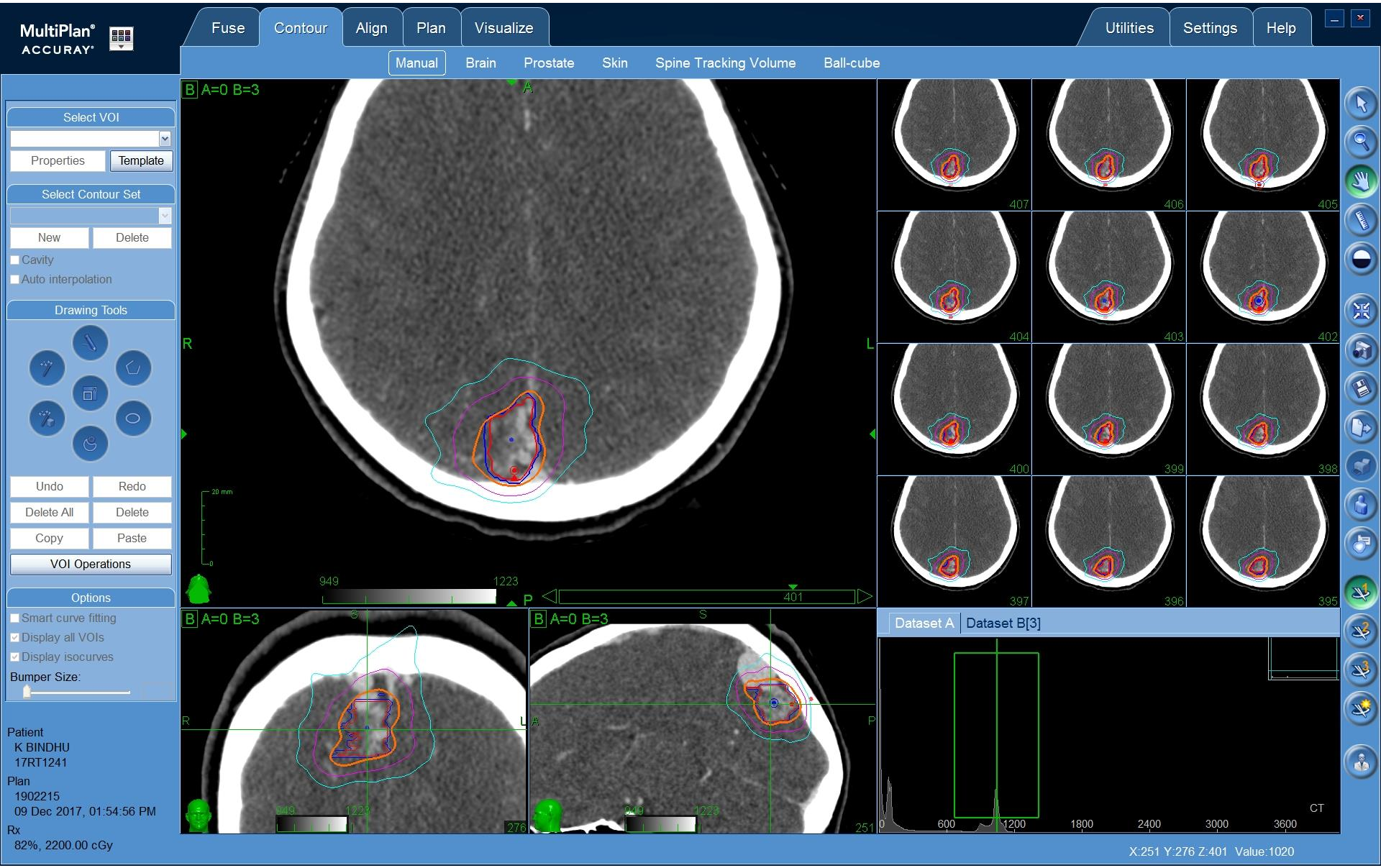
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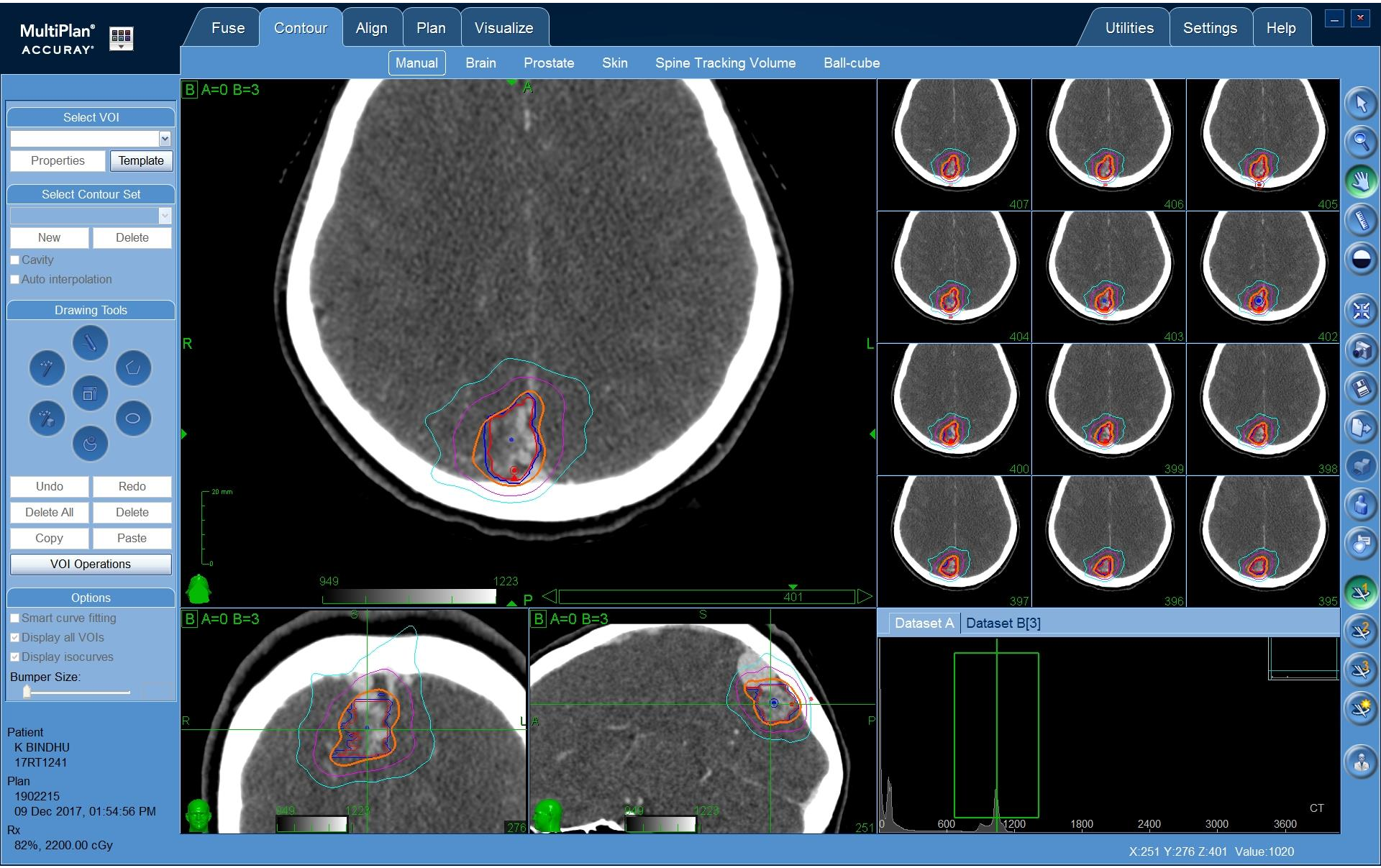
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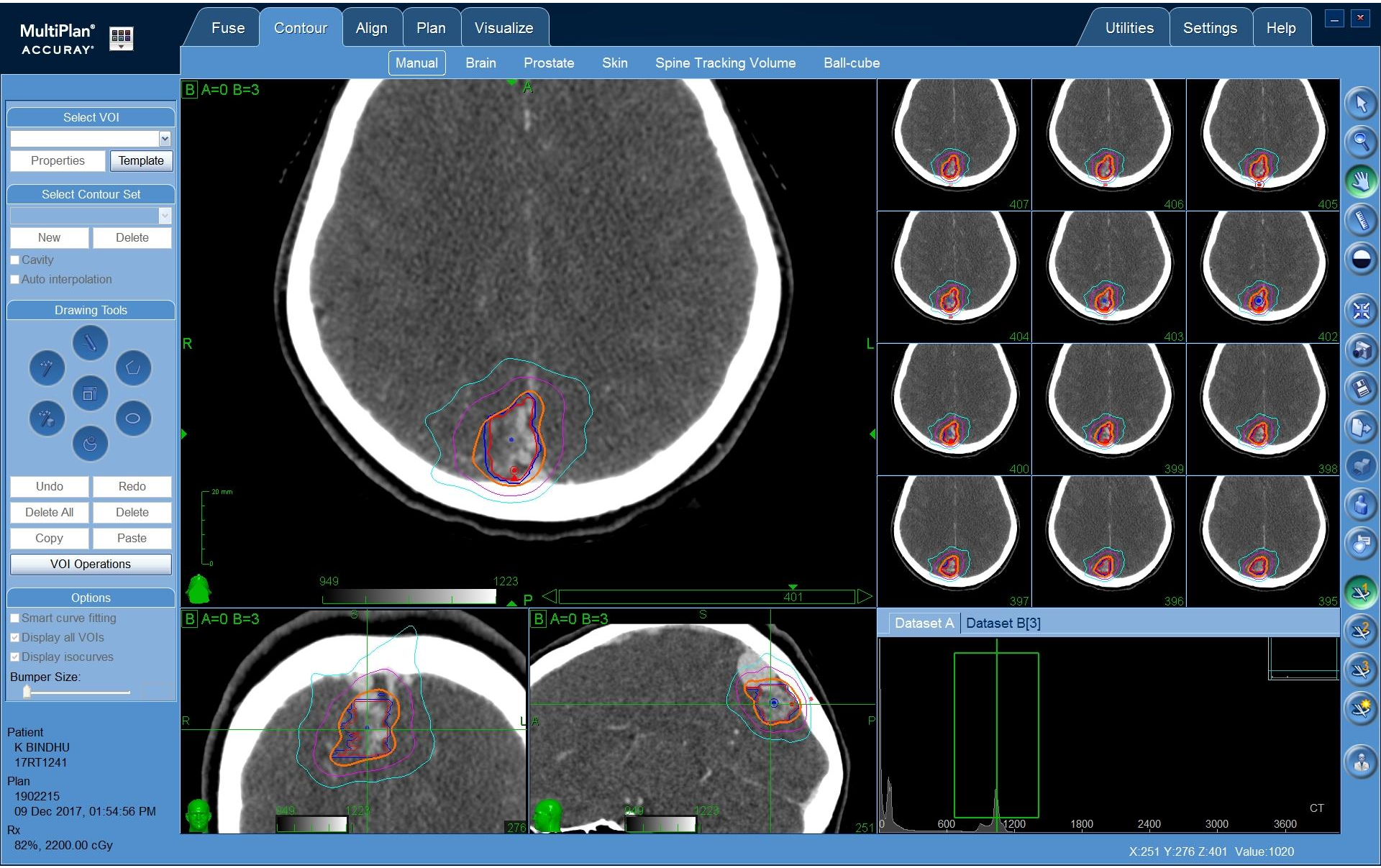
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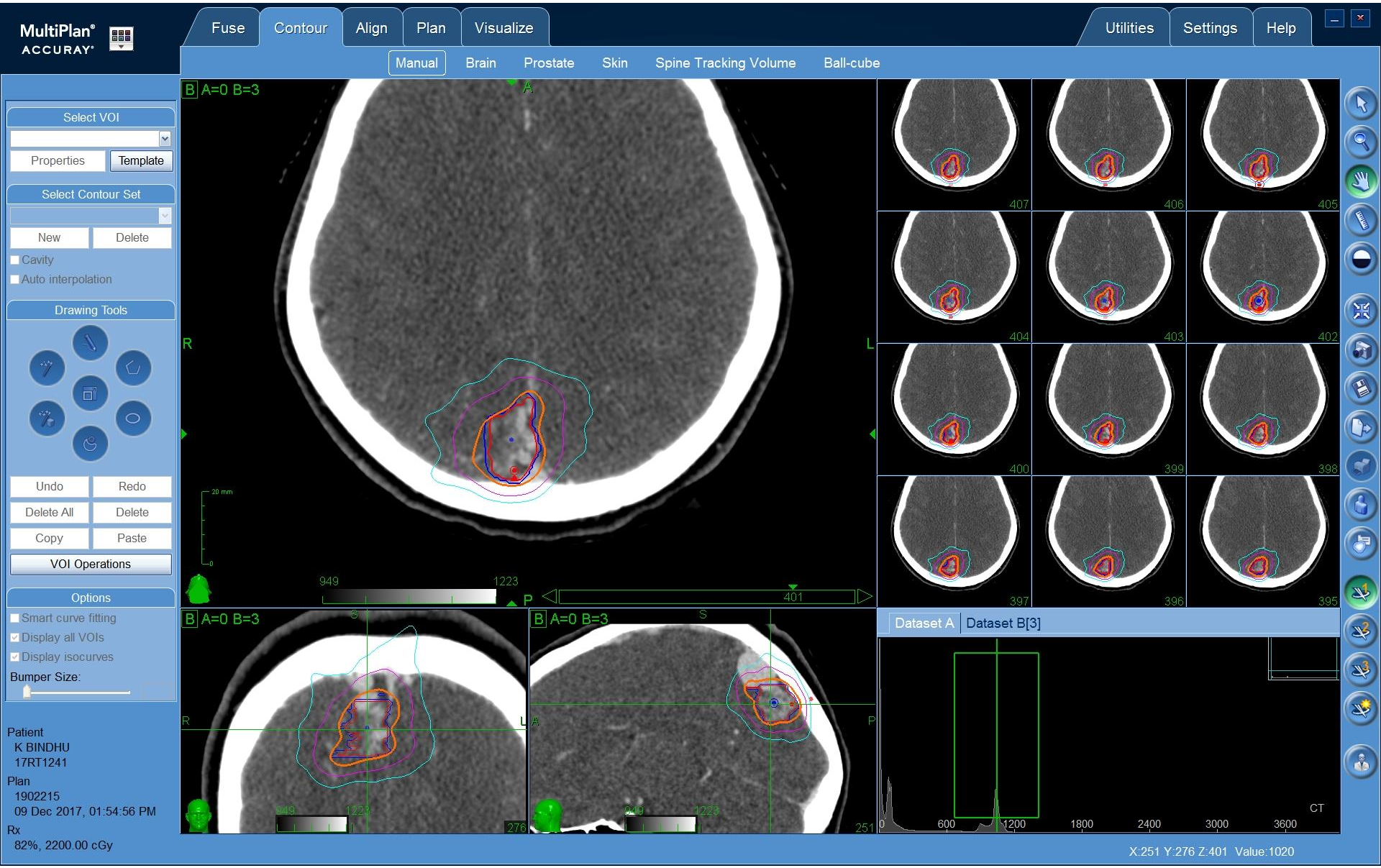
12 Gy Normal brain vol: 17.9 cc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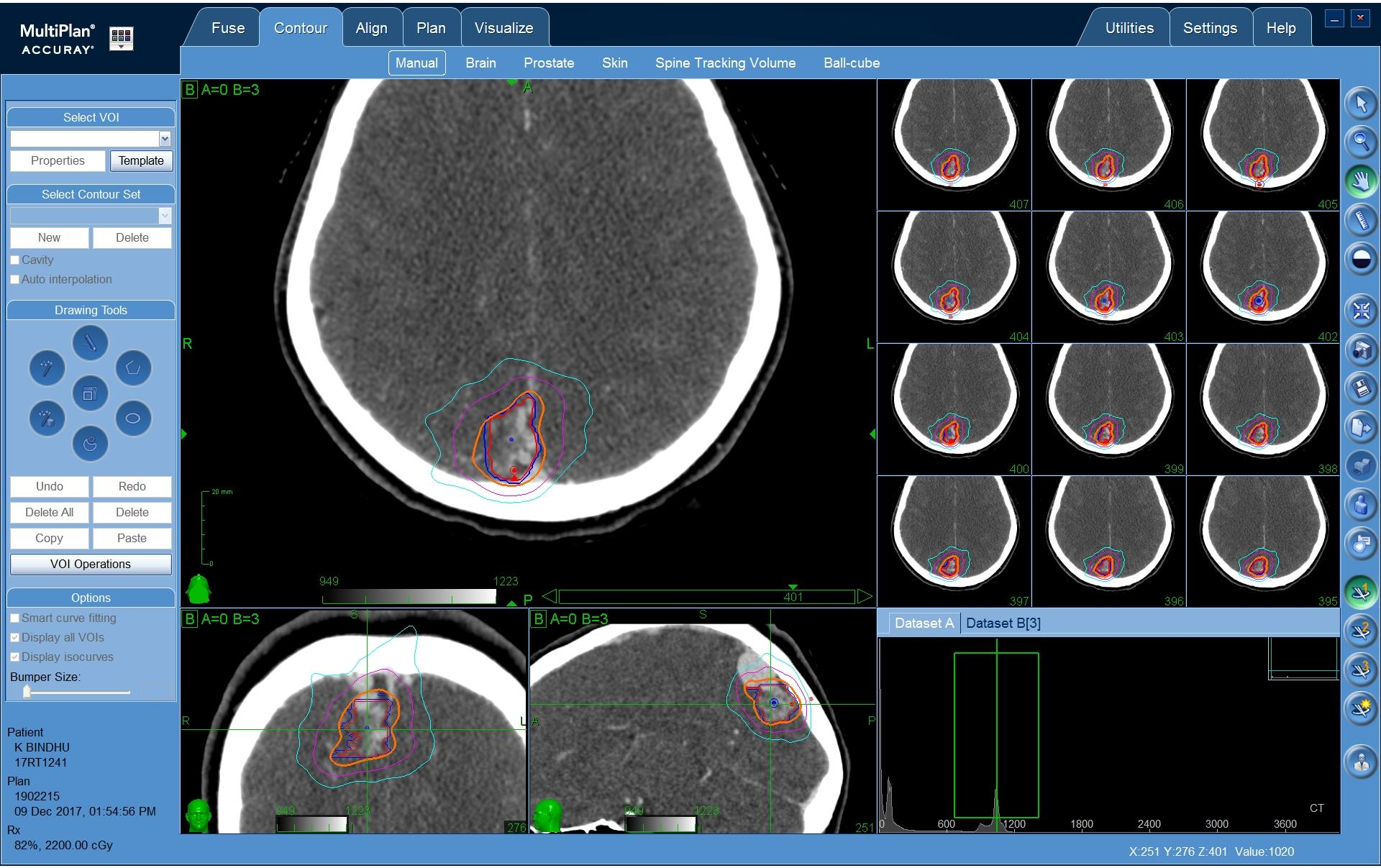
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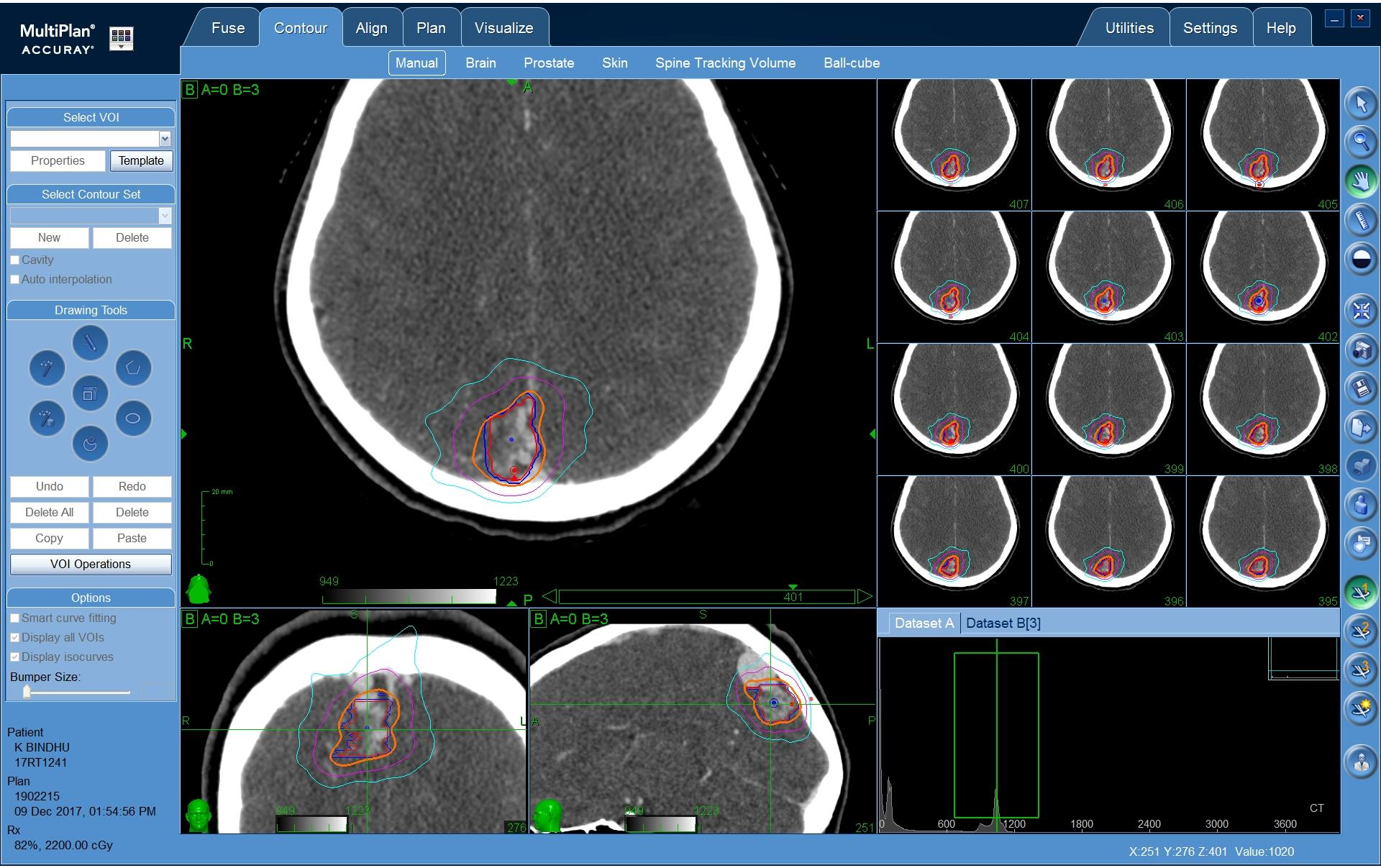
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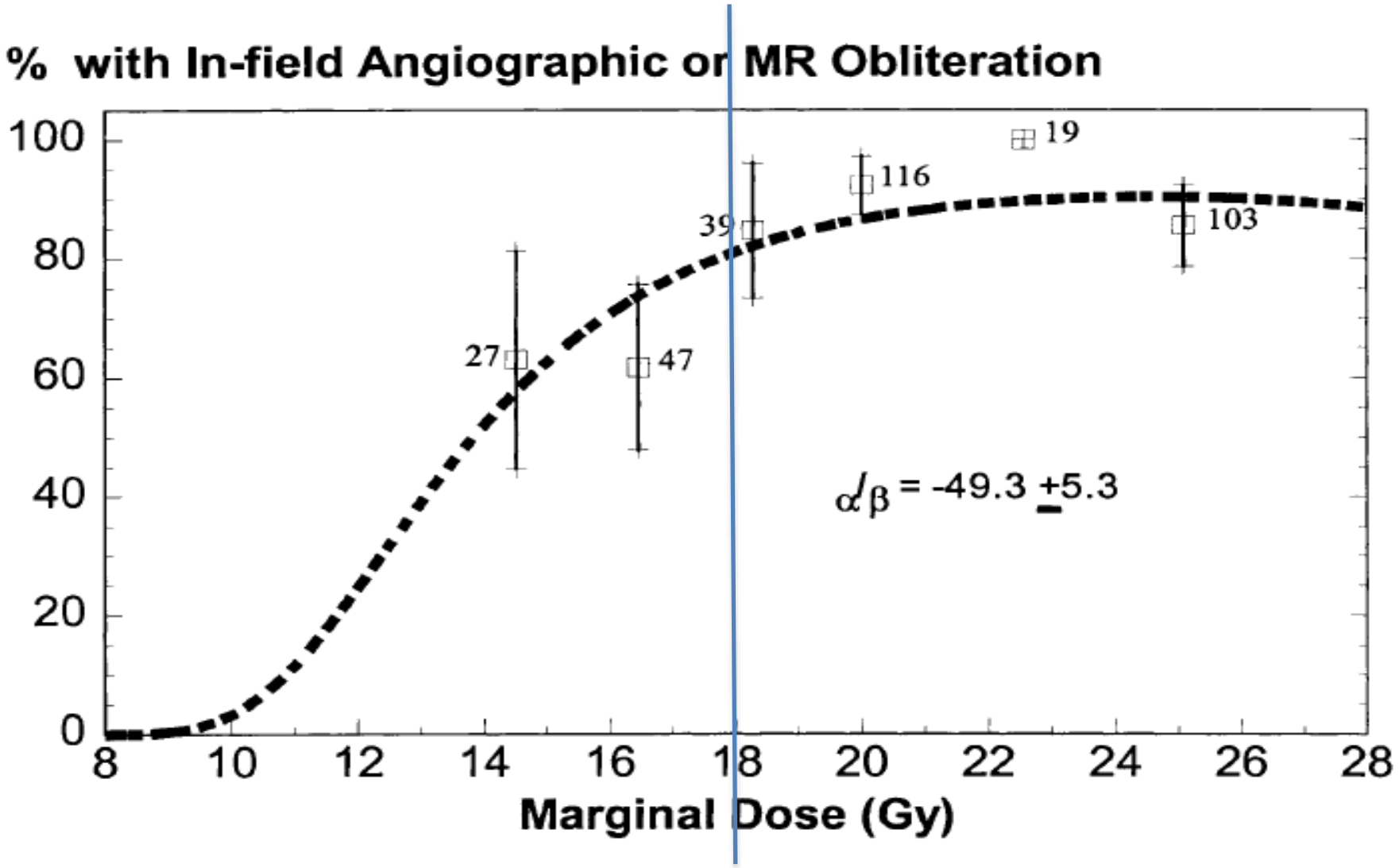
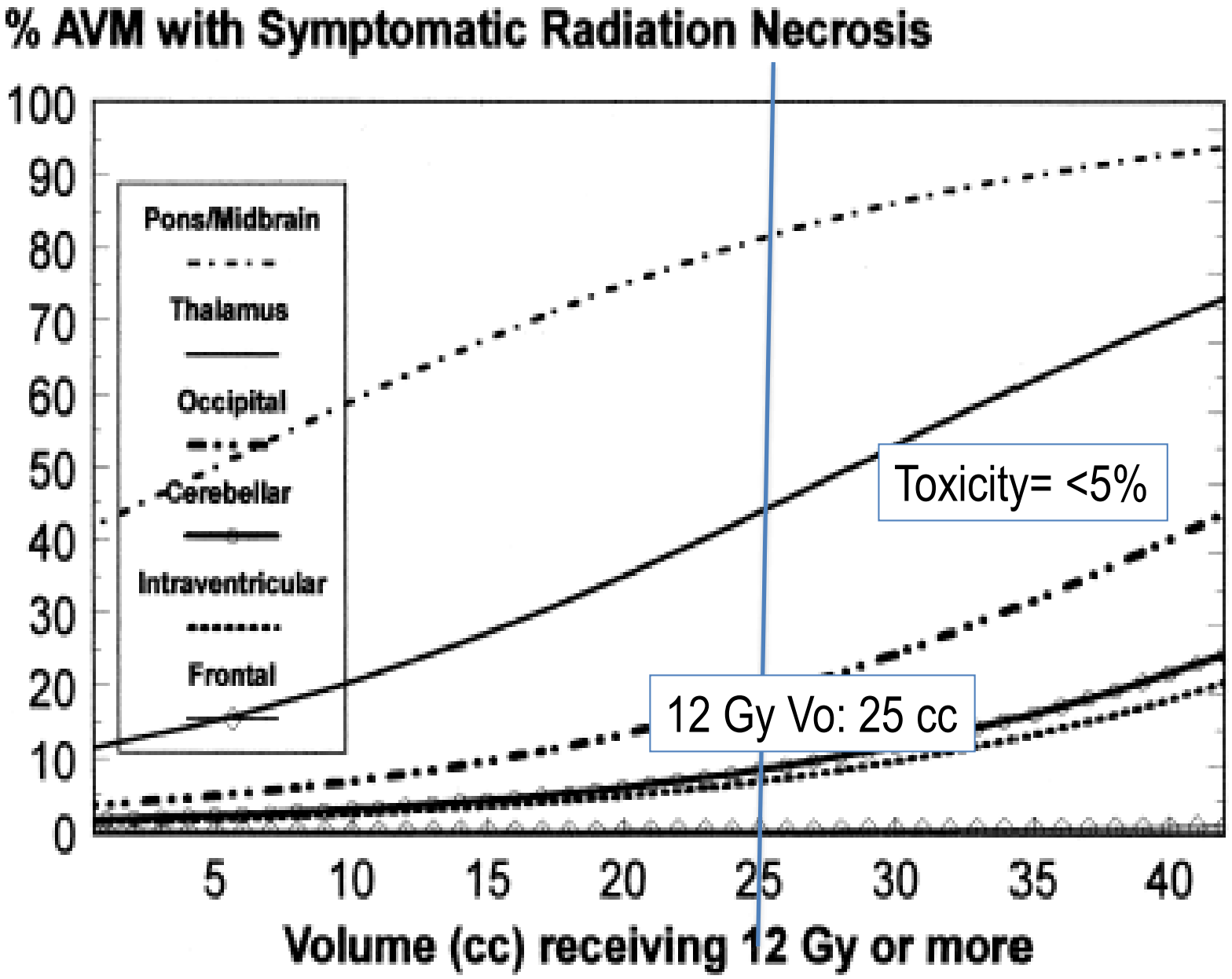
12 Gy Normal brain vol: 19.3 cc



Obliteration rate = 80%

Long-term Toxicity



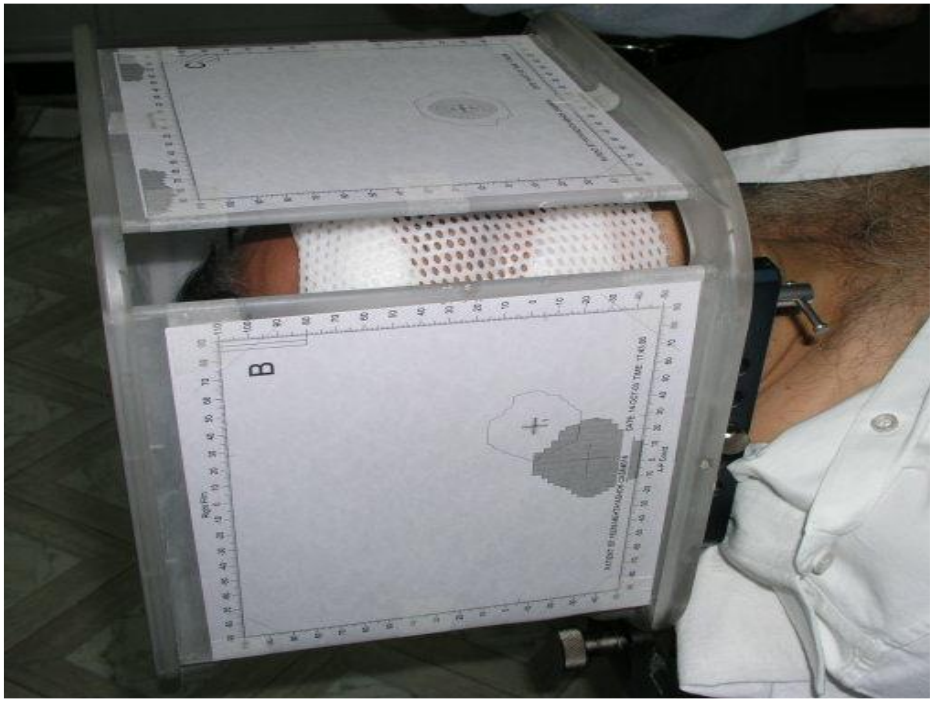
Take HOME

- All cases are different
- Do more cases to learn more
- Individualize treatment accordingly

- Get appropriate imaging
- Excellent immobilization

- Respect OAR Constraints
- Understand required dose

- Discuss



Thank you

duttadeb07@gmail.com