Clinic und Polyclinic for Radioherapy and Radiooncology
Medical Faculty and University Clinic
Carl Gustav Carus
Technical University Dresden

Horst Alheit

IMRT-Planung bei Schädelbasistumoren mit iPlan-dose (BrainLab): Konturierung und Dose-Volume-Constraints

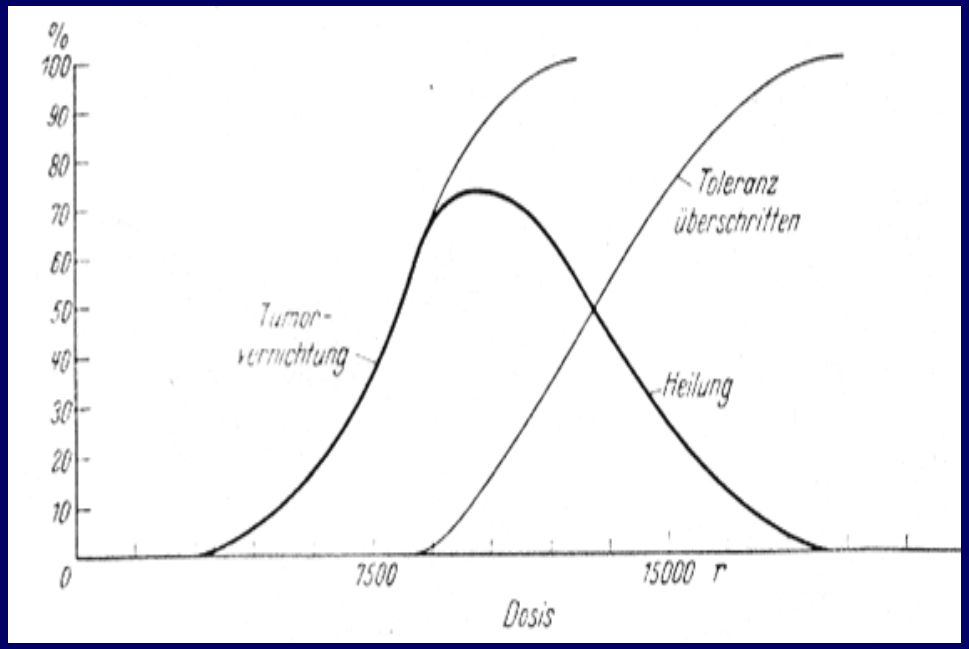
Klinische Motivation zur IMRT

Tumorkontrolle mit möglichst niedriger Toxizität am Normalgewebe

Erfahrungen über die Verträglichkeitsgrenze für Röntgenstrahlen und deren Nutzanwendung zur Verhütung von Schäden*).

Von

H. Holthusen, Hamburg.



Strahlentherapie 57: 254-268,1936

IMRT-Indikation:

- irreguläre ZV nahe an OAR oder diese einschließend
- eingeschränkte Toleranz der OAR (z.B. Vorbestrahlung)

Notwendige Voraussetzungen:

- lokoregionäre Tumor-Ausdehnung
- Visualisierbarkeit der Tumorausdehnung
  - morphologische Bildgebung
  - functionelle Bildgebung
- nachgewiesene Dosis-Effektbeziehung

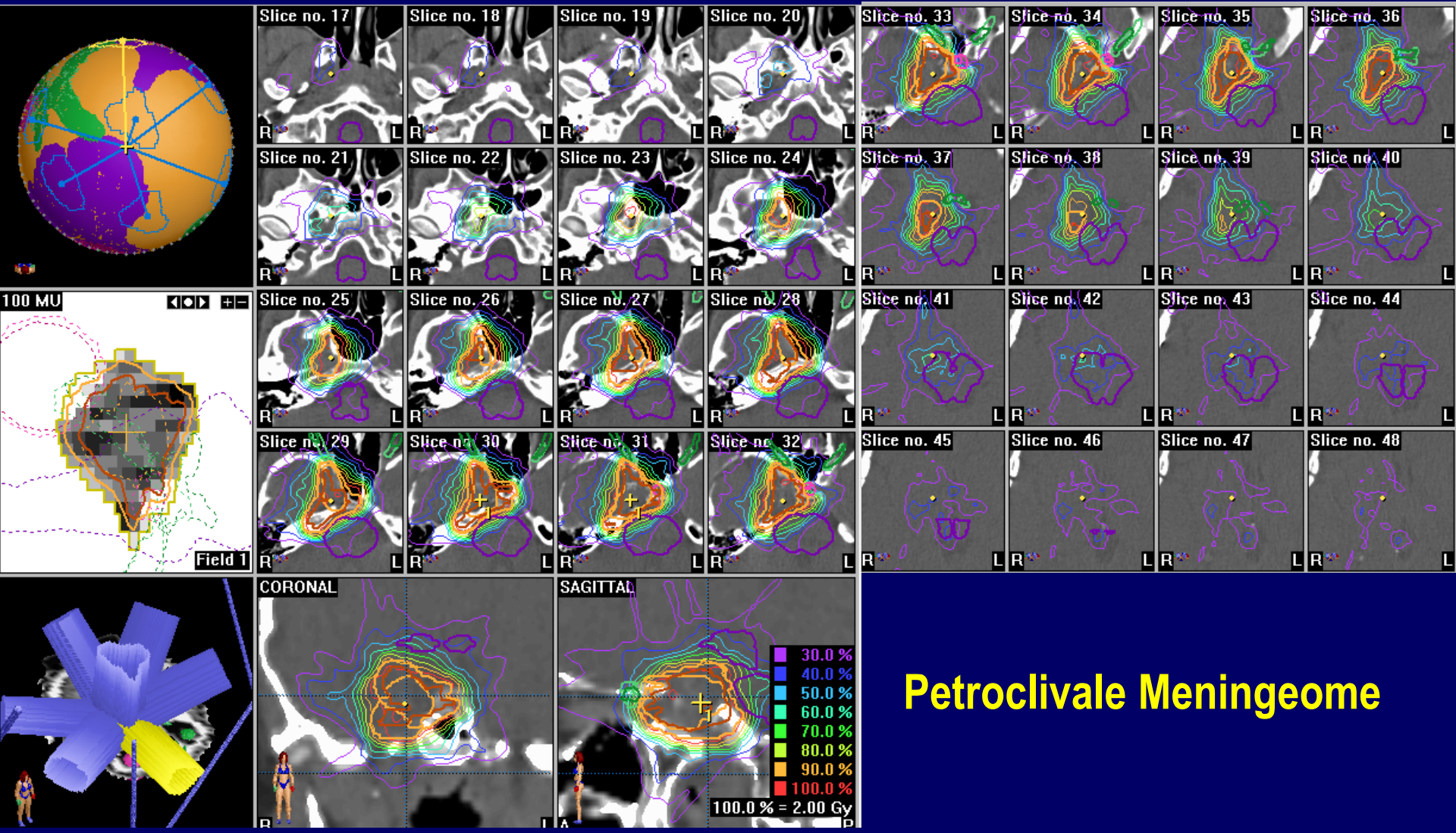
Vorteil der IMRT muß nachgewiesen werden
(Planvergleich mit guten 3Dkonformalem Plan)

Medizinisch wichtige Fragen zur IMRT bei Schädelbasistumoren

- Hochdosisvolumen kleiner (>80%-Isodose)
  - aber Niedrigdosis-Volumen größer (Feldarrangement)
- Schonung von Risikoorganen besser möglich,
  - aber höhere Dosen auf andere Volumina => neue OAR?
- Inverse Planung objektiver?
  - Definition von Dosis-Volumen-Grenzwerten – biologische Basis?
  - biologische Effekte von inhomogenen Dosisverteilungen (ED)
  - Kriterien für Plan-Selektion?
- Welche set-up Genauigkeit ist erforderlich?

->IMRT ist keine Wunderwaffe, die alle Probleme löst!

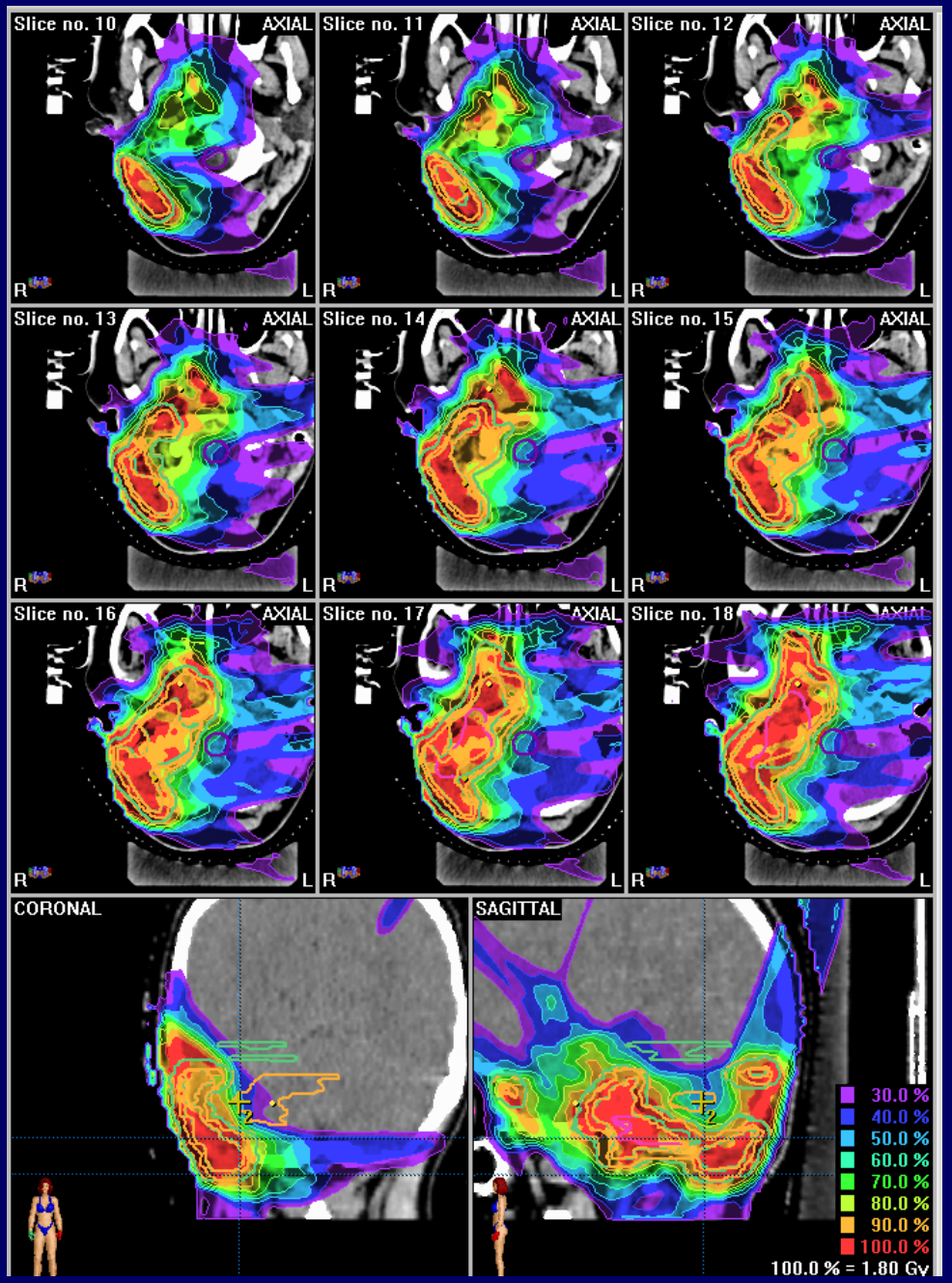
Klinische Beispiele 1



Petroclivale Meningeome

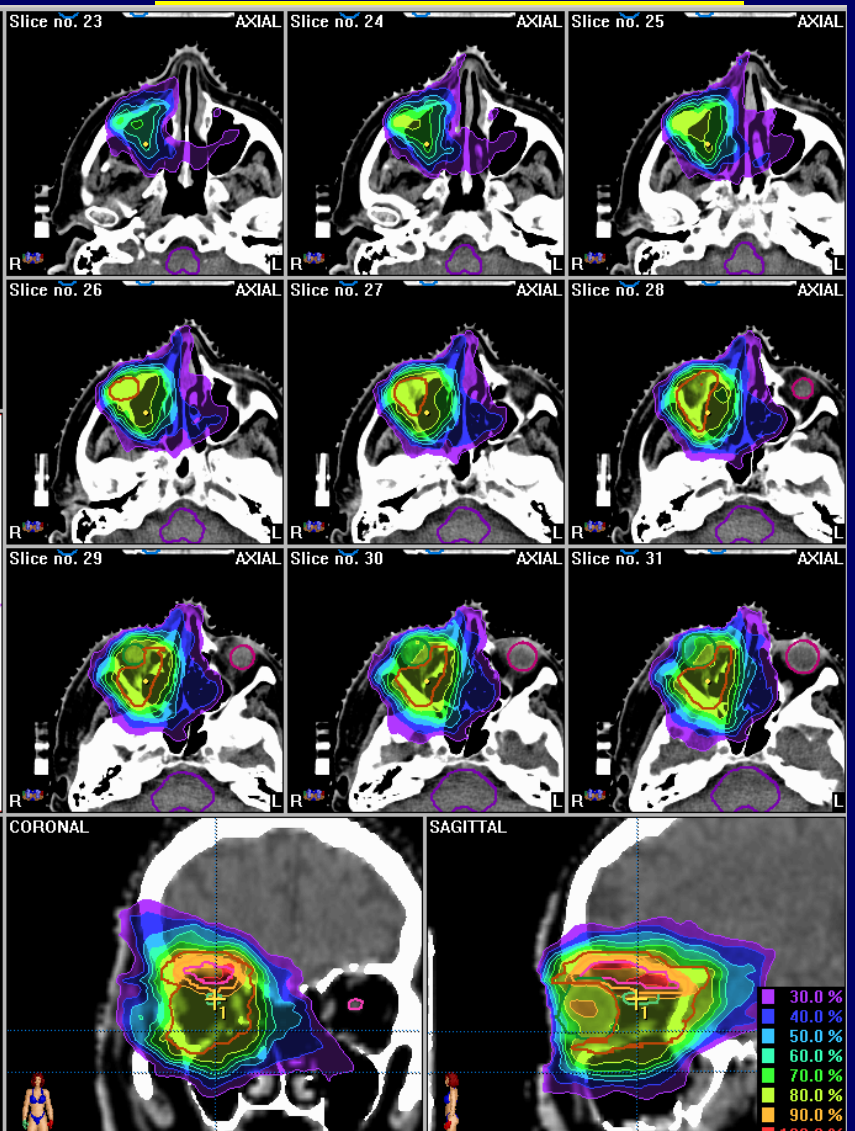
Klinische Beispiele 2

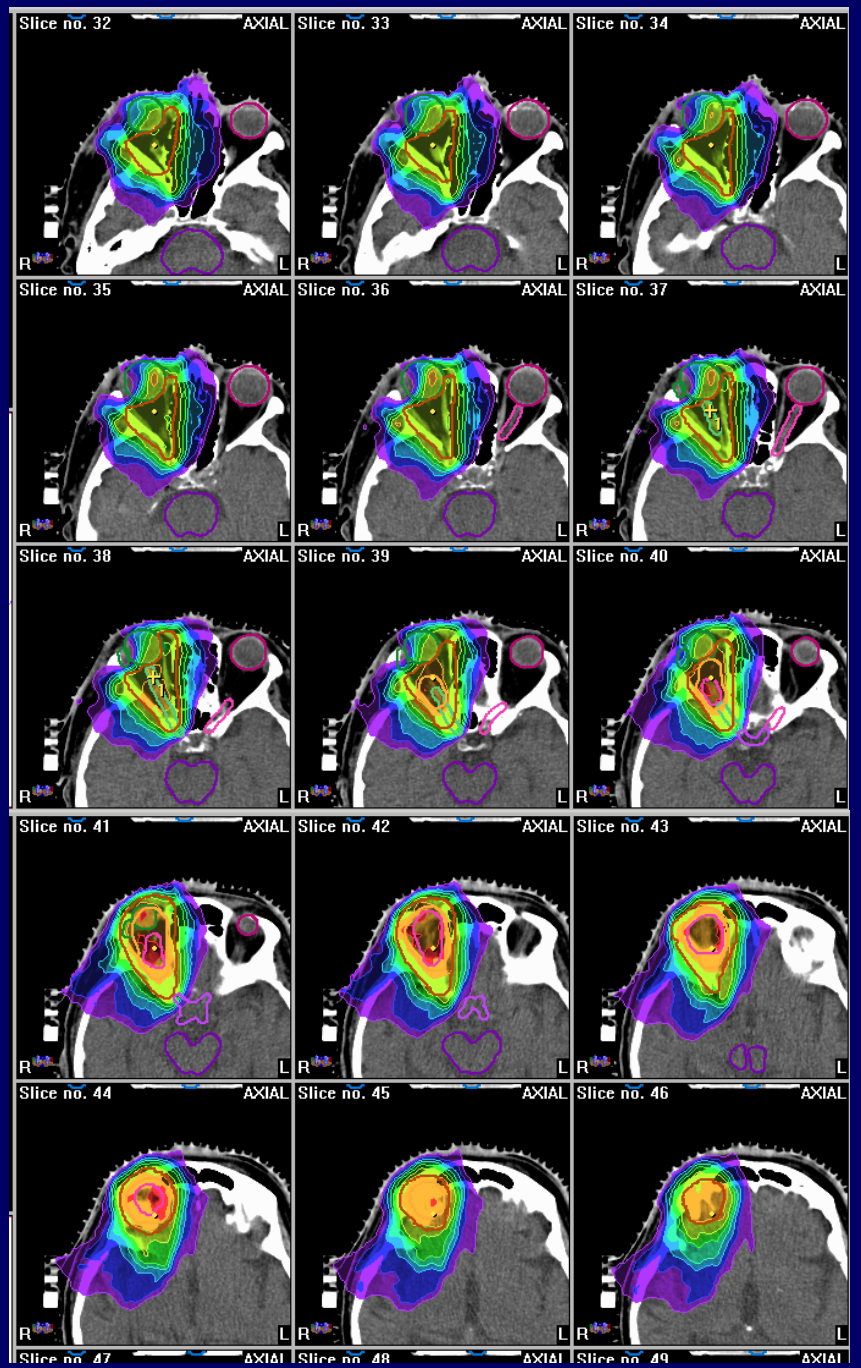
Meningeom multilokulär



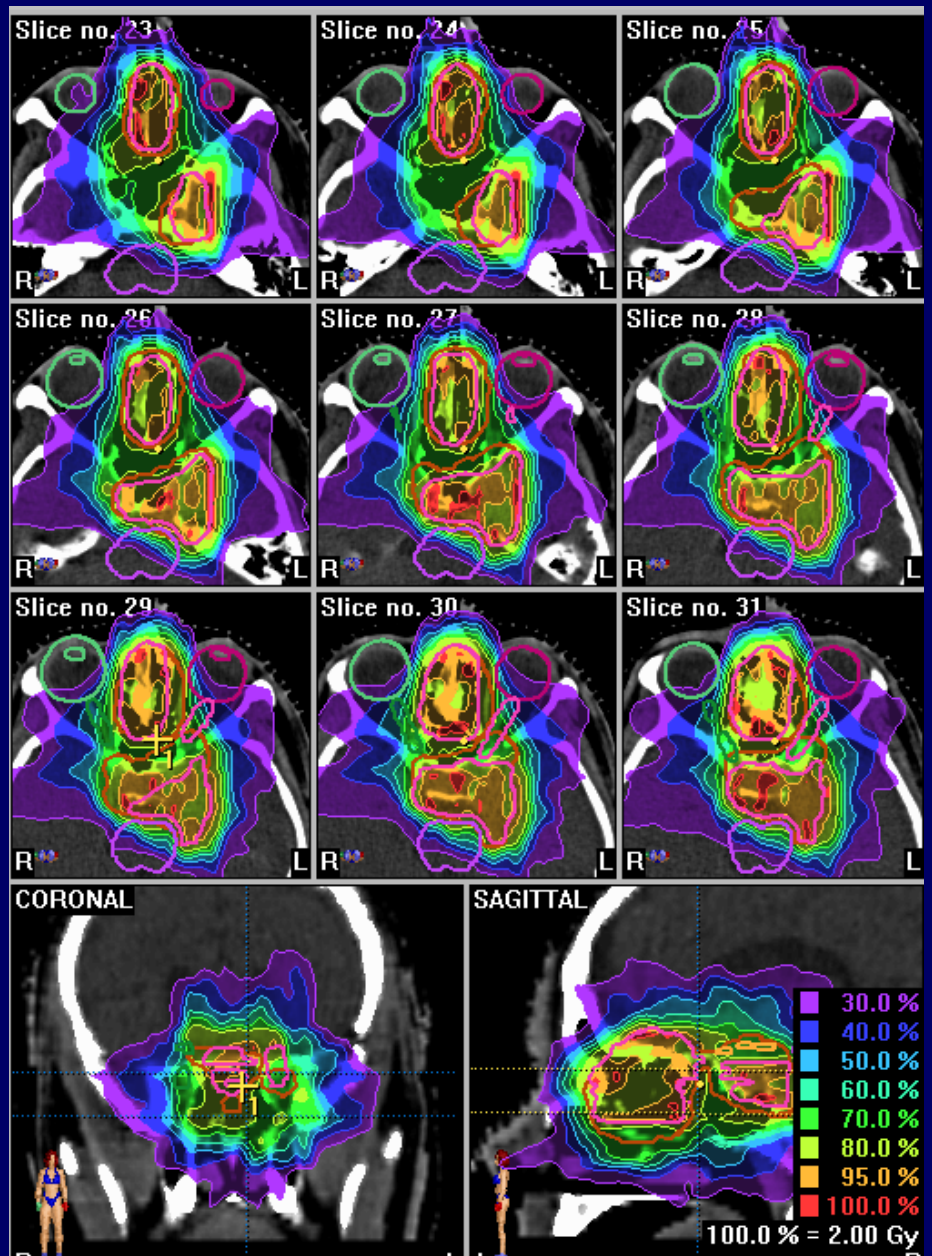
Klinische Beispiele 3

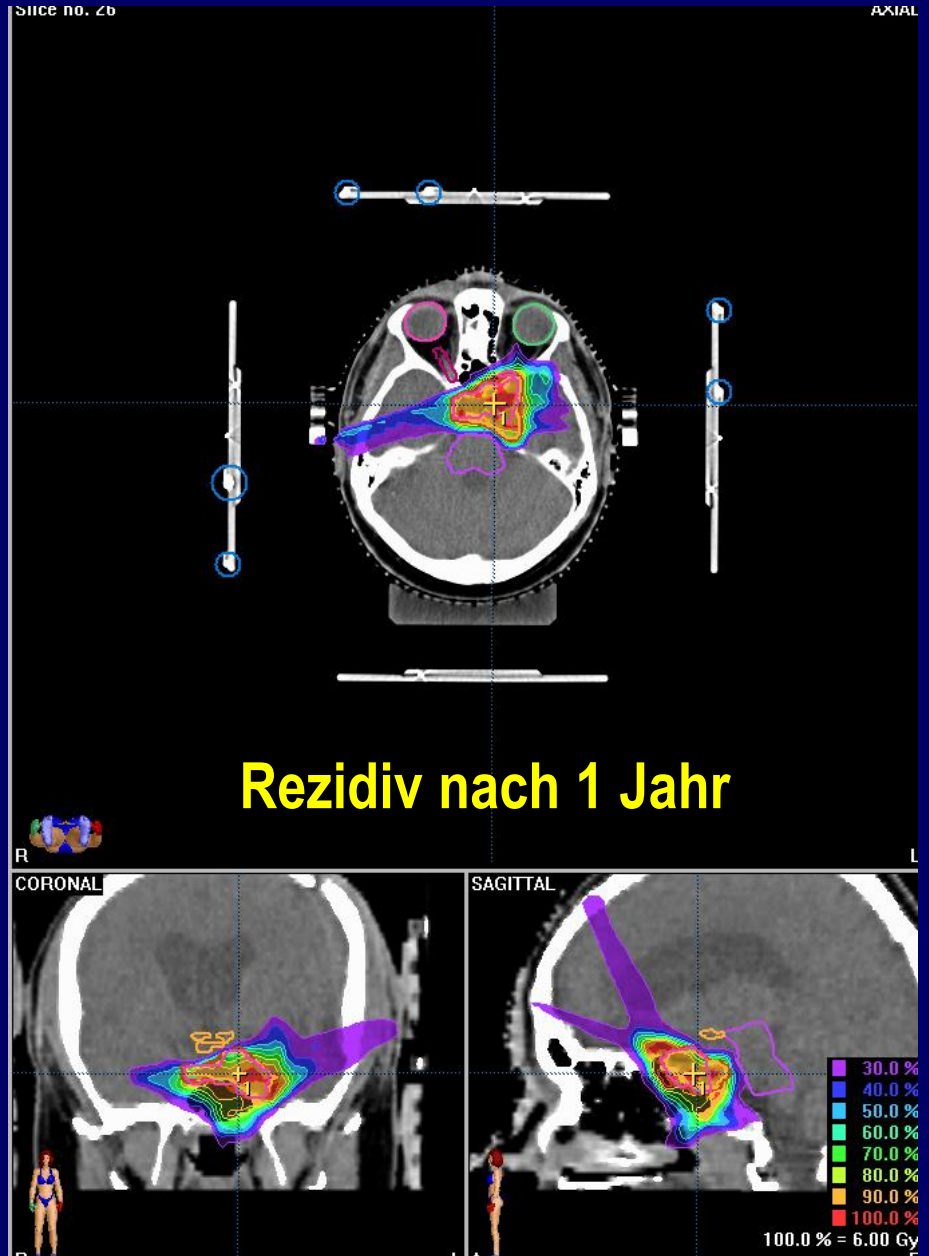
Orbita-Tumor



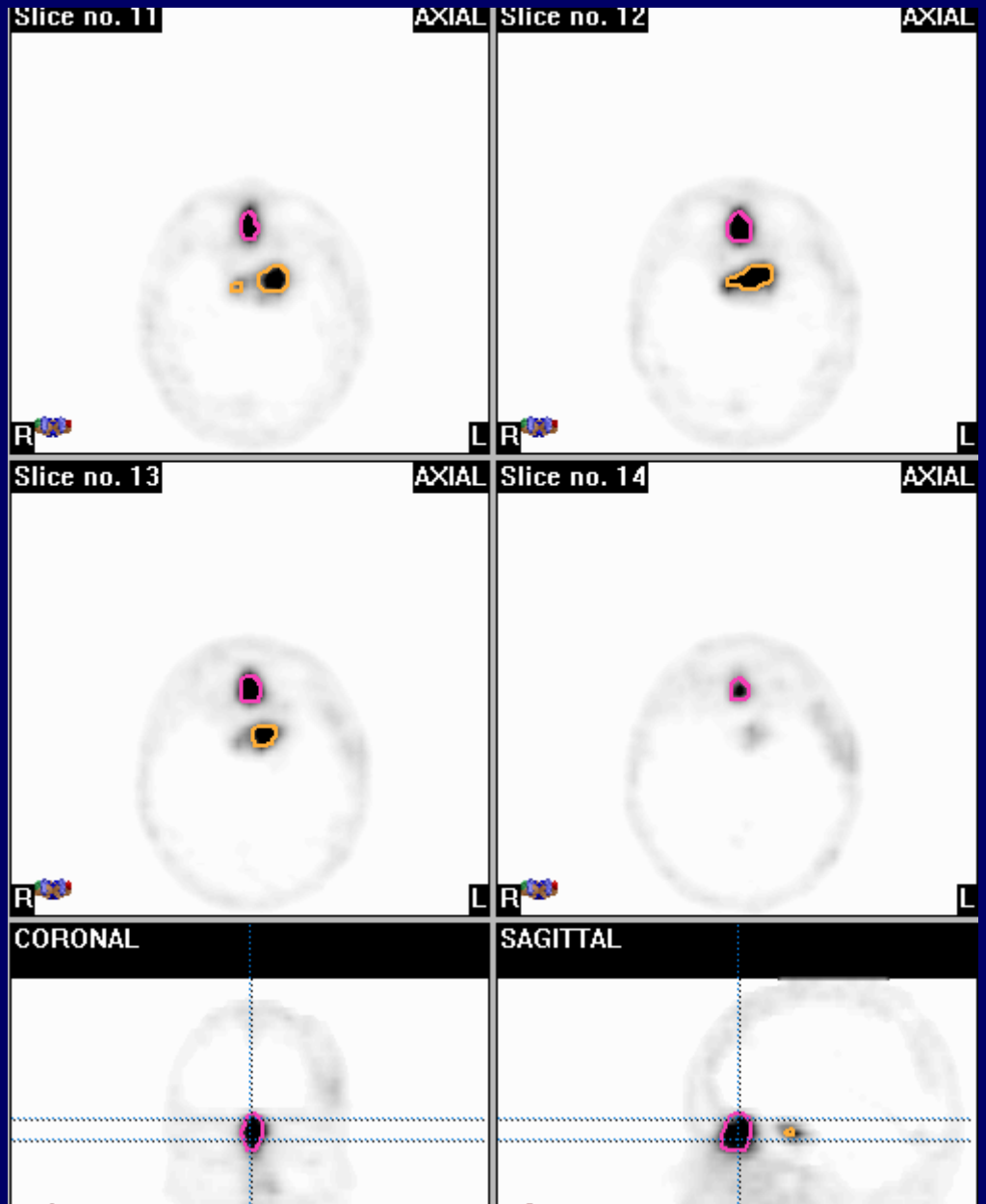


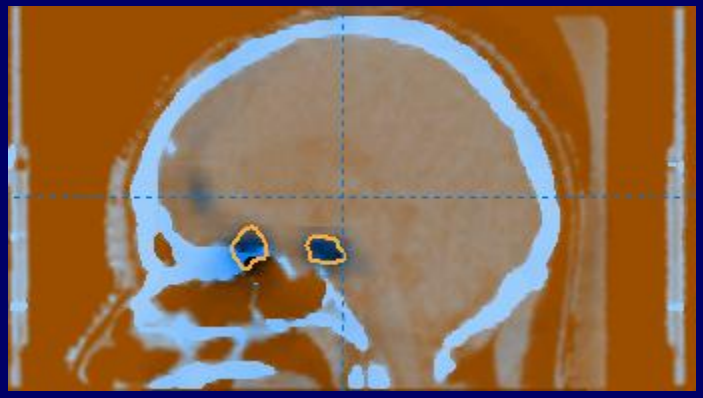
Klinische Beispiele 3 - Hypophysenadenom

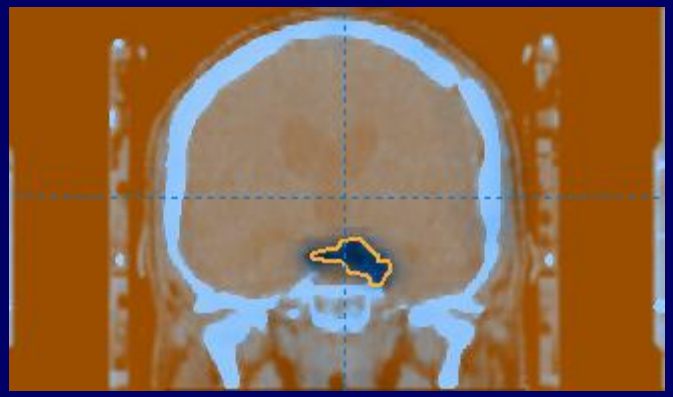


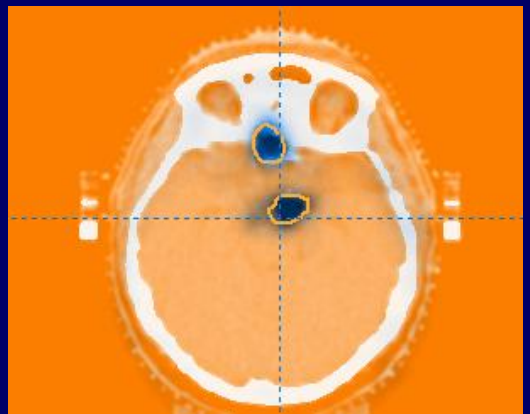


Lokoregionäre Ausdehnung- Visualisierbarkeit





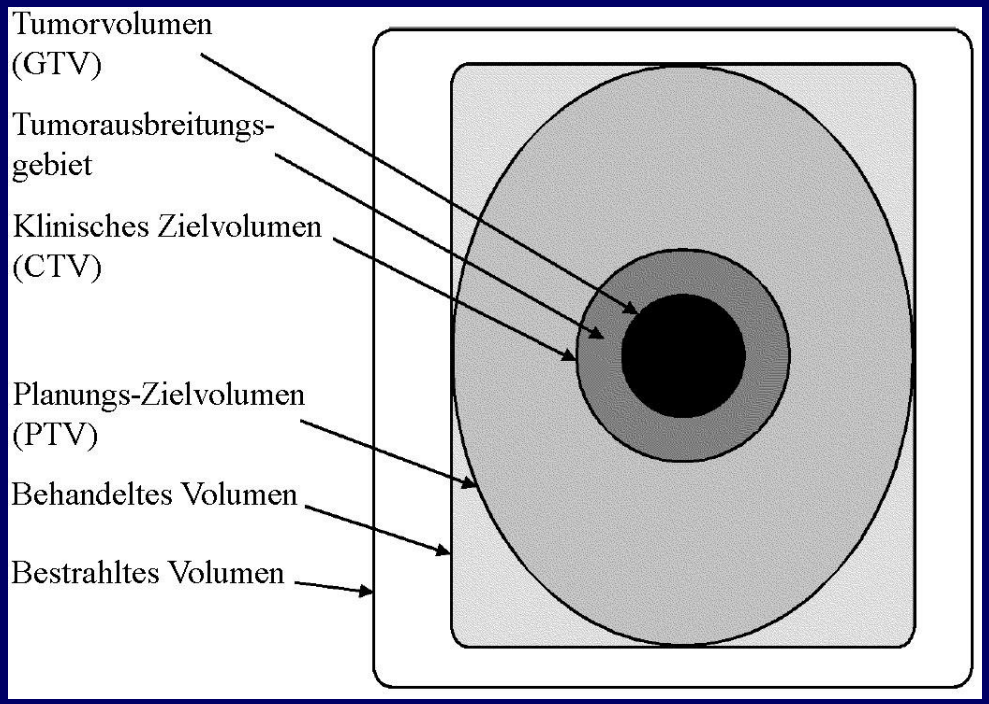


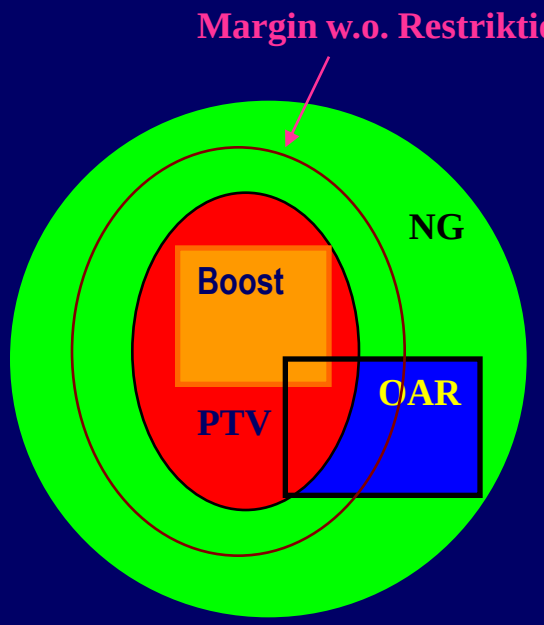


Dosis-Volumen-Beschränkungen

- Es werden nur Objekte berücksichtigt, die den Status PTV, Boost-Objekt oder OAR haben
- Da Boost-Objekte als Teil des PTV gelten, die eine höhere Dosis erhalten, werden nur überlappende Bereiche von Boost und PTV berücksichtigt, Überschneidungen mehrerer Boostobjekte sind nicht zulässig
- MLC-Formung erfolgt unter Berücksichtigung der Sicherheitssäume bei primärer Feldfestlegung nach PTV

Volumenkonzepte





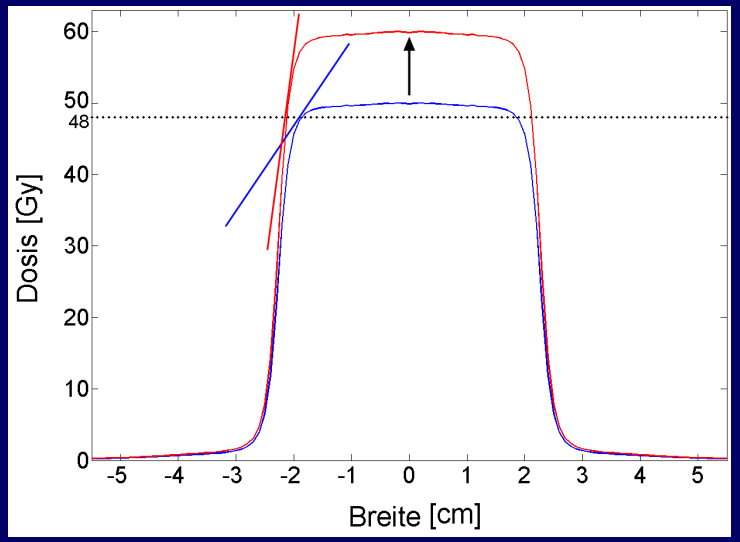
DGMP-Bericht Nr.11 [DP98] und im ICRU Report 50 bzw. 62 [IU93, IU99] definiert sind.

iPlan:

- Boostvoxel= gelten nur im PTV
- alle anderen Voxel im PTV = PTV
- OAR nur aßerhalb PTV gültig
- alle nicht def. Voxel =Normalgewebe

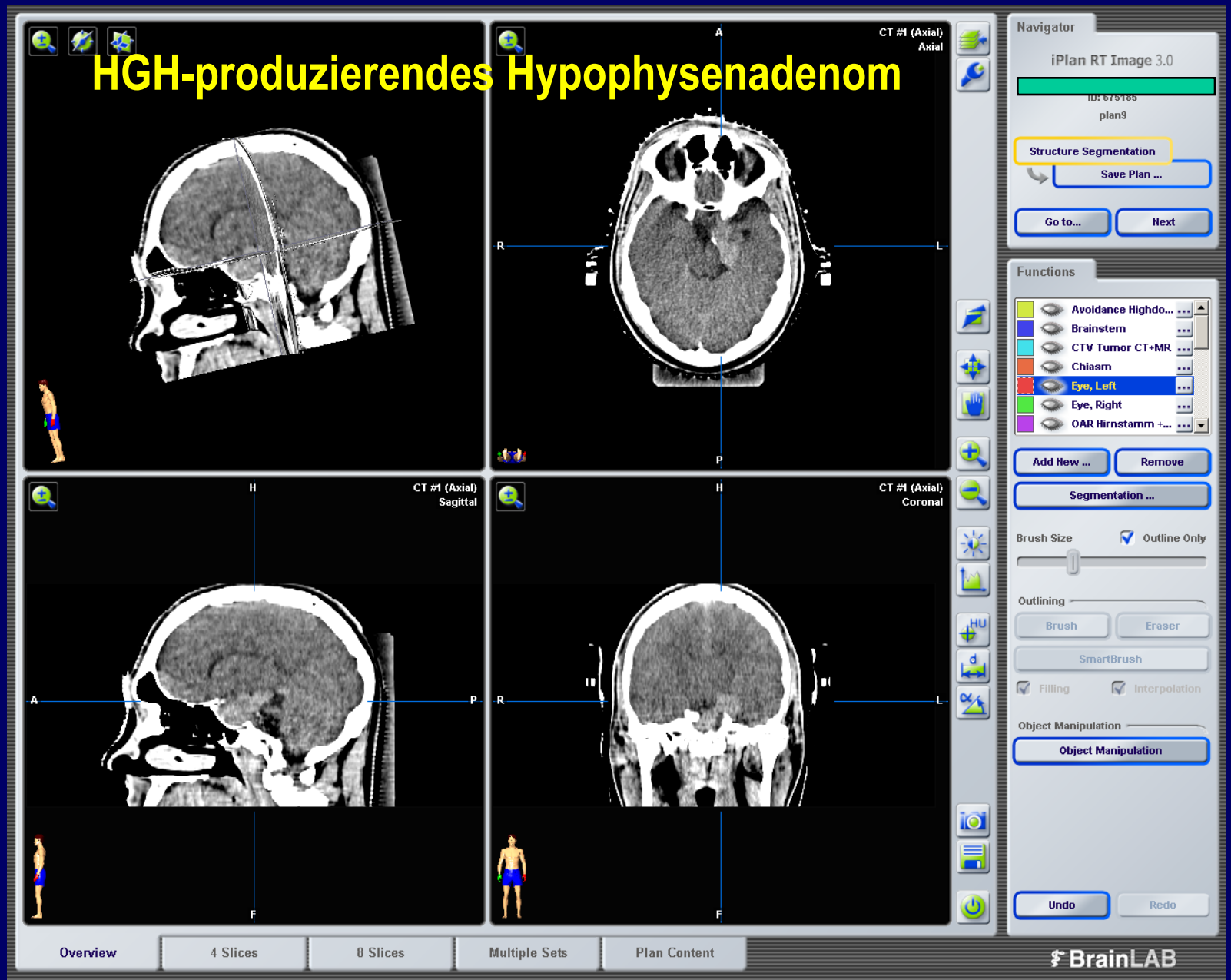
Klinische Dosisverschreibungen

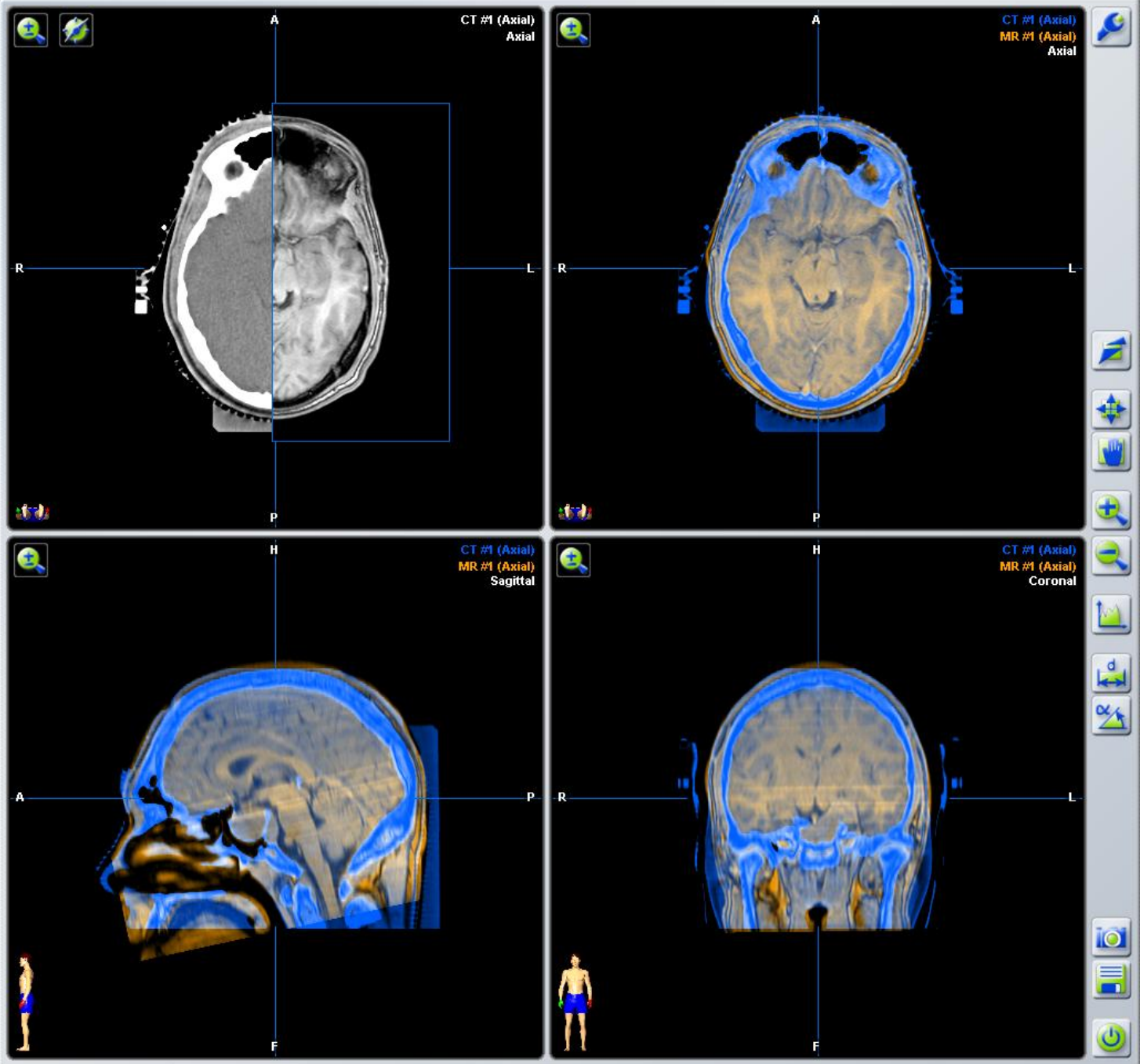
Volumen	Dosis [Gy]
PTV	50 (mind. 48)
„Boost“	60
Chiasma opticum, Nervus optici	max. 54
Hirnstamm	max. 54
Augen (Netzhaut)	max. 40
Linse	max. 6
Normalgewebe	max. 18



Wegen steilem Gradient PTV mit 80%-Isodose erfaßt -> Randdosis 48 Gy bedingt 60 Gy/100%

Konturierung





Navigator

iPlan RT Image 3.0

ID: 675185

plan9

Image Fusion

Structure Segmentation

Go to...

Next

Functions

CT #1 (Axial) -MR #1 (Axial)

Add new ...

Reset

Blue

Amber

Edges

Edges

Manual Fusion

Coarse

Fine

Automatic Fusion

AutoFUSE

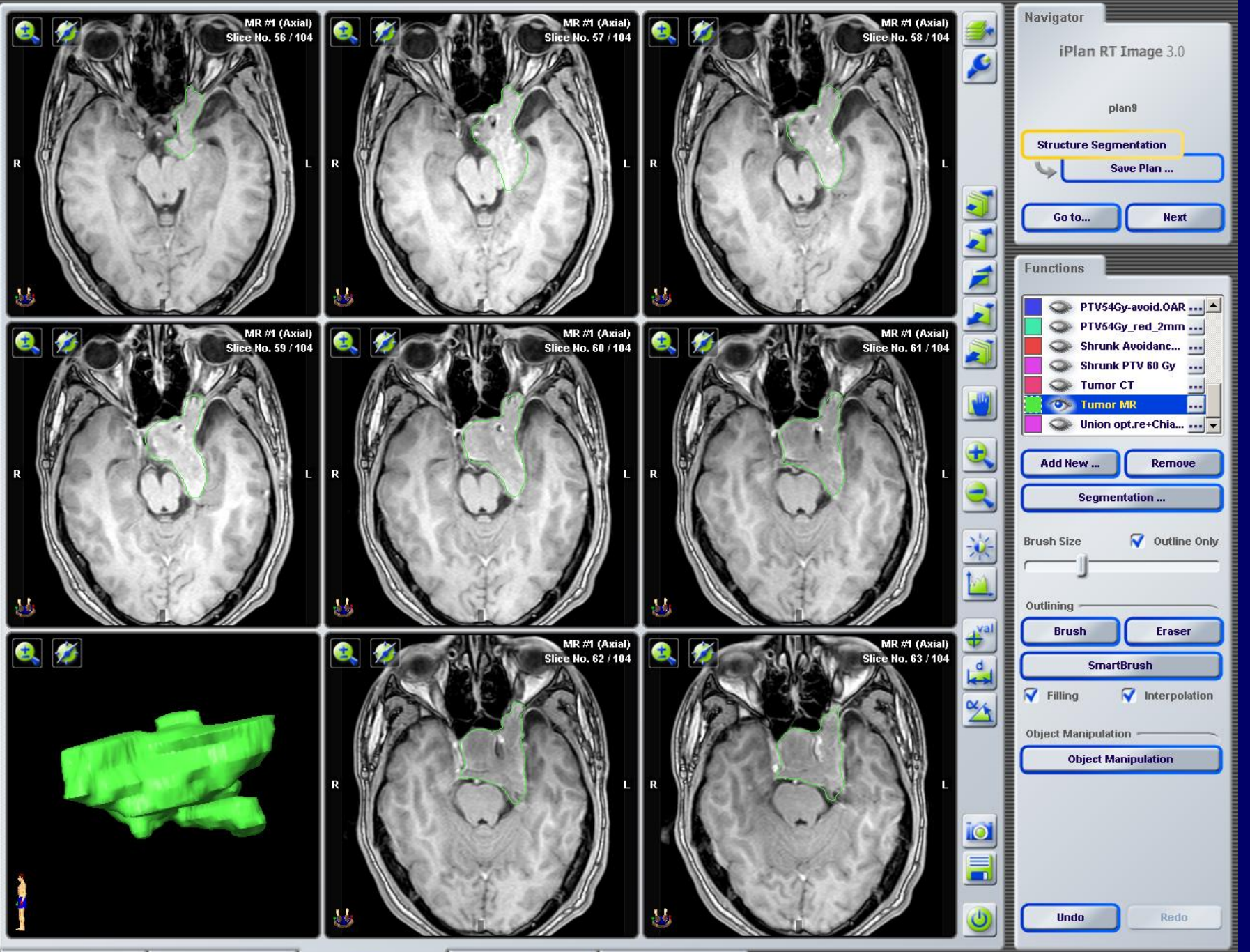
Modify Range...

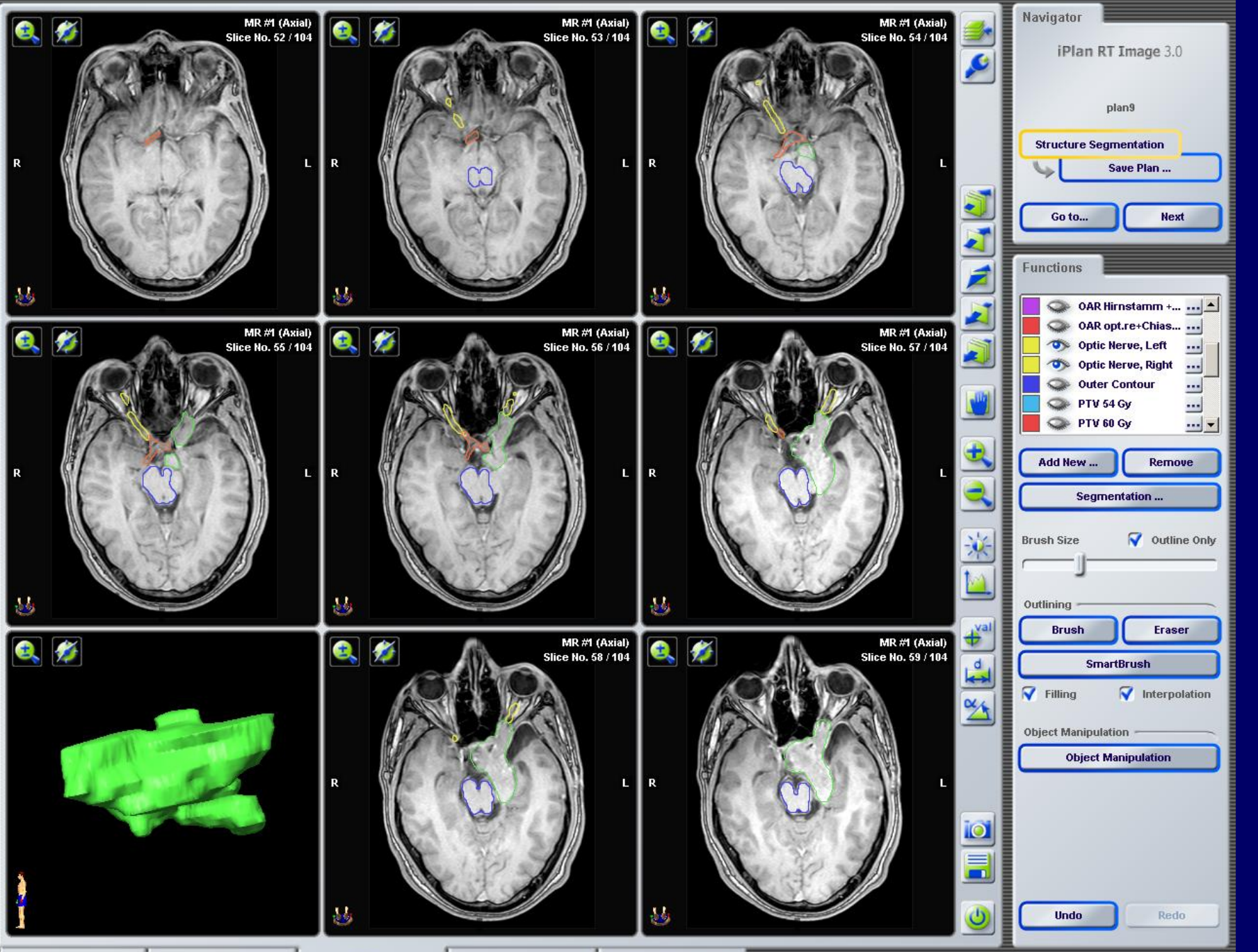
Undo

Redo

Overview

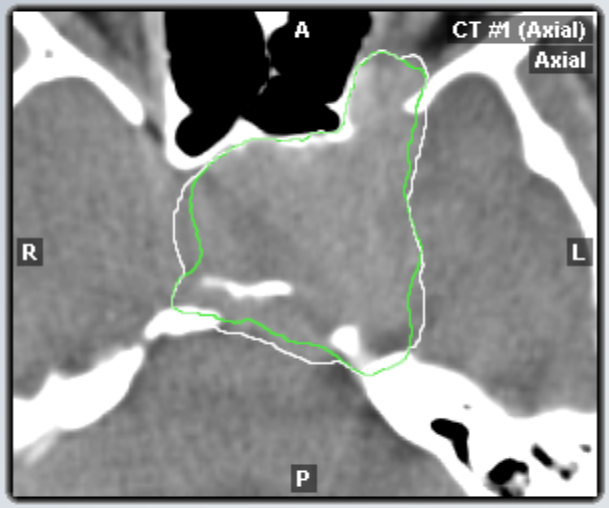
BrainLAB

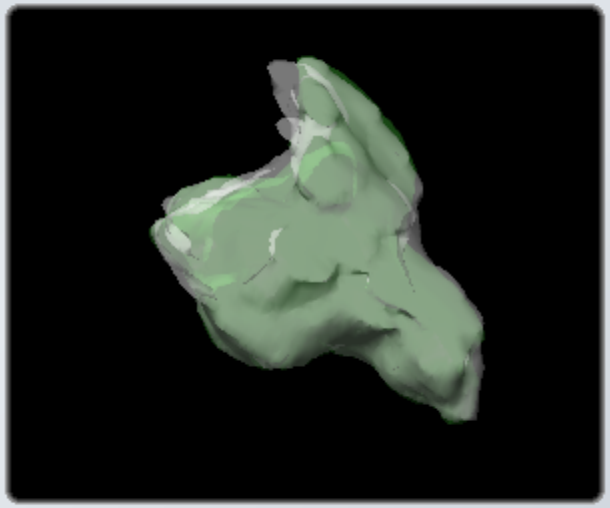

MR #1 (Axial)
Slice No. 56 / 104
MR #1 (Axial)
Slice No. 57 / 104
MR #1 (Axial)
Slice No. 58 / 104
MR #1 (Axial)
Slice No. 59 / 104
MR #1 (Axial)
Slice No. 60 / 104
MR #1 (Axial)
Slice No. 61 / 104
MR #1 (Axial)
Slice No. 62 / 104
MR #1 (Axial)
Slice No. 63 / 104
R
L
Navigator
iPlan RT Image 3.0
plan9
Structure Segmentation
Save Plan ...
Go to...
Next
Functions
PTV54Gy-avoid.OAR
PTV54Gy_red_2mm
Shrunk Avoidanc...
Shrunk PTV 60 Gy
Tumor CT
Tumor MR
Union opt.re+Chia...
Add New ...
Remove
Segmentation ...
Brush Size
Outline Only
Outlining
Brush
Eraser
SmartBrush
Filling
Interpolation
Object Manipulation
Object Manipulation
Undo
Redo
Overview
4 Slices
8 Slices
Multiple Sets
Plan Content
BrainLAB


MR #1 (Axial)
Slice No. 52 / 104
MR #1 (Axial)
Slice No. 53 / 104
MR #1 (Axial)
Slice No. 54 / 104
MR #1 (Axial)
Slice No. 55 / 104
MR #1 (Axial)
Slice No. 56 / 104
MR #1 (Axial)
Slice No. 57 / 104
MR #1 (Axial)
Slice No. 58 / 104
MR #1 (Axial)
Slice No. 59 / 104
R
L
Navigator
iPlan RT Image 3.0
plan9
Structure Segmentation
Save Plan ...
Go to...
Next
Functions
OAR Hirnstamm +...
OAR opt.re+Chias...
Optic Nerve, Left
Optic Nerve, Right
Outer Contour
PTV 54 Gy
PTV 60 Gy
Add New ...
Remove
Segmentation ...
Brush Size
Outline Only
Outlining
Brush
Eraser
SmartBrush
Filling
Interpolation
Object Manipulation
Object Manipulation
Undo
Redo
Overview
4 Slices
8 Slices
Multiple Sets
Plan Content
BrainLAB

Morphology | Boolean Operations

Preview





First Operand

- PTV54Gy-avoid.OAR
- PTV54Gy_red_2mm
- Shrunk Avoidance Hig...
- Shrunk PTV 60 Gy
- **Tumor CT**
- Tumor MR
- Union opt.re+Chiasma

Second Operand

- PTV mind. 54 Gy
- PTV54Gy-avoid.OAR
- PTV54Gy_red_2mm
- Shrunk Avoidance Hig...
- Shrunk PTV 60 Gy
- **Tumor MR**
- Union opt.re+Chiasma

Boolean Merge Mode

(•) Union ( ) Intersection ( ) Subtraction

New Object

Name: CTV (CT+MR)

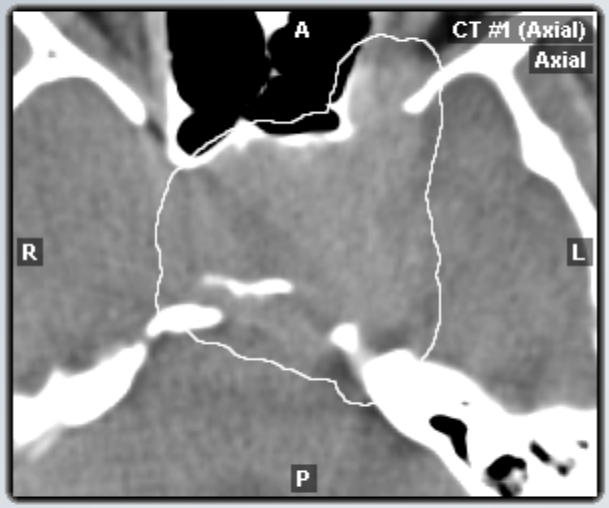
Volume: 46.507 cm³

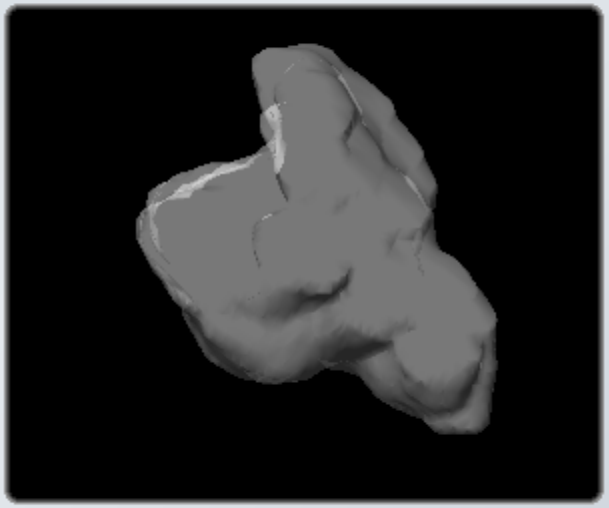
Generate

OK | Cancel

Morphology | Boolean Operations

Preview





Source Object

- Avoidance Highdose
- Brainstem
- CTV Tumor CT+MR
- Chiasm
- Eye, Left
- Eye, Right
- OAR Hirnstamm +3mm

Operation

- (•) Enlarge Object
- ( ) Shrink Object
- ( ) Create Wall

Parameters

L	3.0 mm	R	3.0 mm	☑ proportional
A	3.0 mm	P	3.0 mm	☑ proportional
H	3.0 mm	F	3.0 mm	☑ proportional

☑ Clip with Outer Contour

New Object

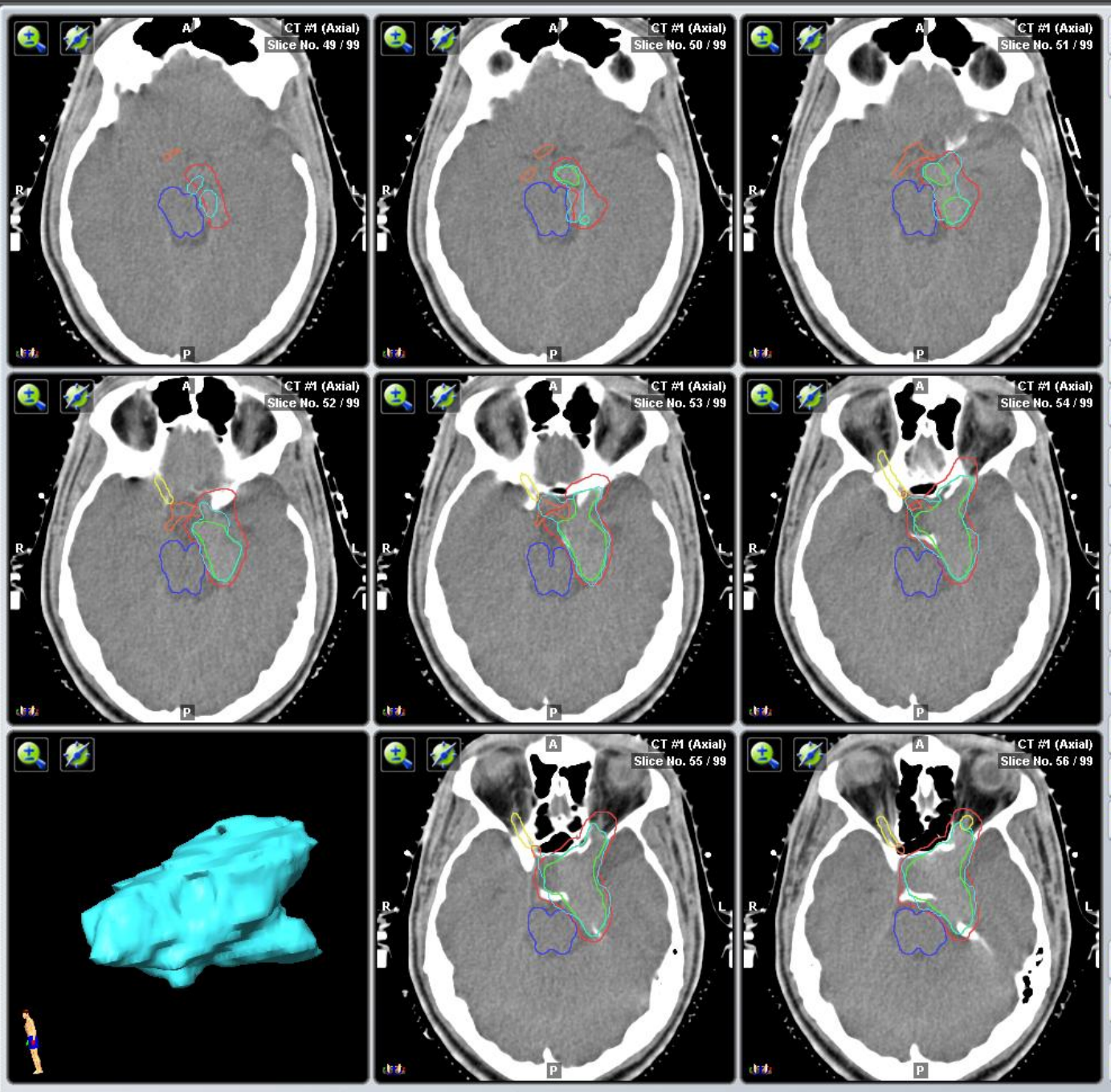
Name: PTV min 54 Gy

Volume:

75.589 cm³

Generate

OK | Cancel



Navigator

iPlan RT Image 3.0

Verebelyi^Jonny
ID: 675185

plan9

Structure Segmentation

Save Plan ...

Go to... | Next

Functions

- OAR opt.re+Chias...
- Optic Nerve, Left
- Optic Nerve, Right
- Outer Contour
- PTV 54 Gy
- PTV 60 Gy
- PTV mind. 54 Gy

Add New ... | Remove

Segmentation ...

Brush Size | Outline Only

Outlining

Brush | Eraser

SmartBrush

Filling | Interpolation

Object Manipulation

Object Manipulation

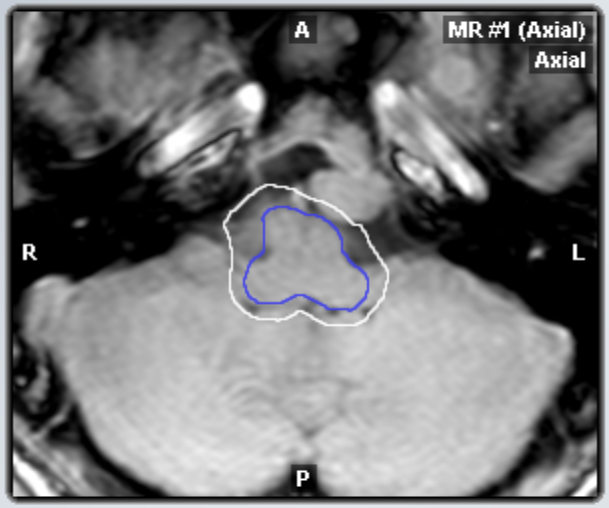
Undo | Redo

Overview | 4 Slices | 8 Slices | Multiple Sets | Plan Content

BrainLAB

Morphology | Boolean Operations

Preview



Source Object

- Avoidance Highdose
- Brainstem
- CTV Tumor CT+MR
- Chiasm
- Eye, Left
- Eye, Right
- OAR Hirnstamm +3mm

Operation

- (•) Enlarge Object
- ( ) Shrink Object
- ( ) Create Wall

Parameters

L	3.0	mm	R	3.0	mm	proportional
A	3.0	mm	P	3.0	mm	proportional
H	3.0	mm	F	3.0	mm	proportional

[x] Clip with Outer Contour

New Object

Name: OAR Hirnstamm+3mm

Volume:

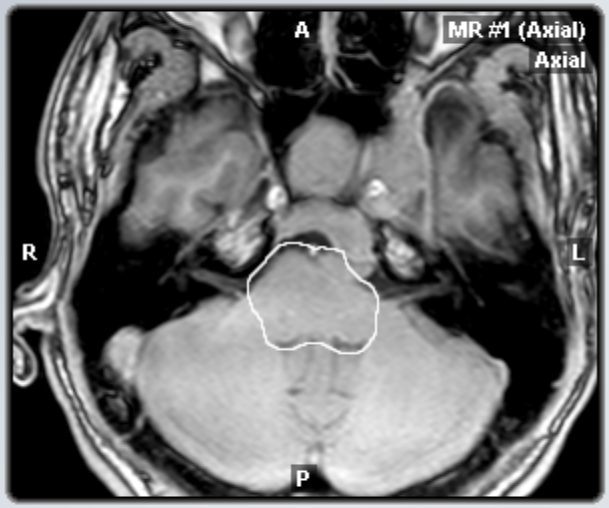
59.375 cm³

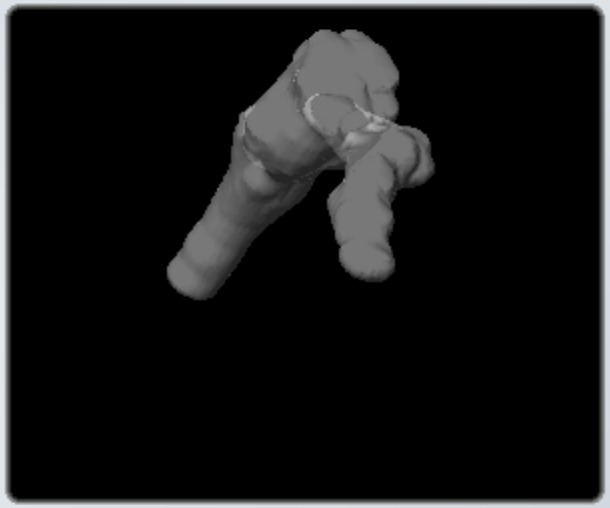
Generate

OK | Cancel

Morphology | Boolean Operations

Preview





First Operand

- Eye, Left
- Eye, Right
- OAR Hirnstamm +3mm
- OAR opt.re+Chiasma+5...
- Optic Nerve, Left
- Optic Nerve, Right
- PTV 54 Gy

Second Operand

- Avoidance Highdose
- Brainstem
- CTV Tumor CT+MR
- Chiasm
- Eye, Left
- Eye, Right
- OAR opt.re+Chiasma+5...

Boolean Merge Mode

(•) Union ( ) Intersection ( ) Subtraction

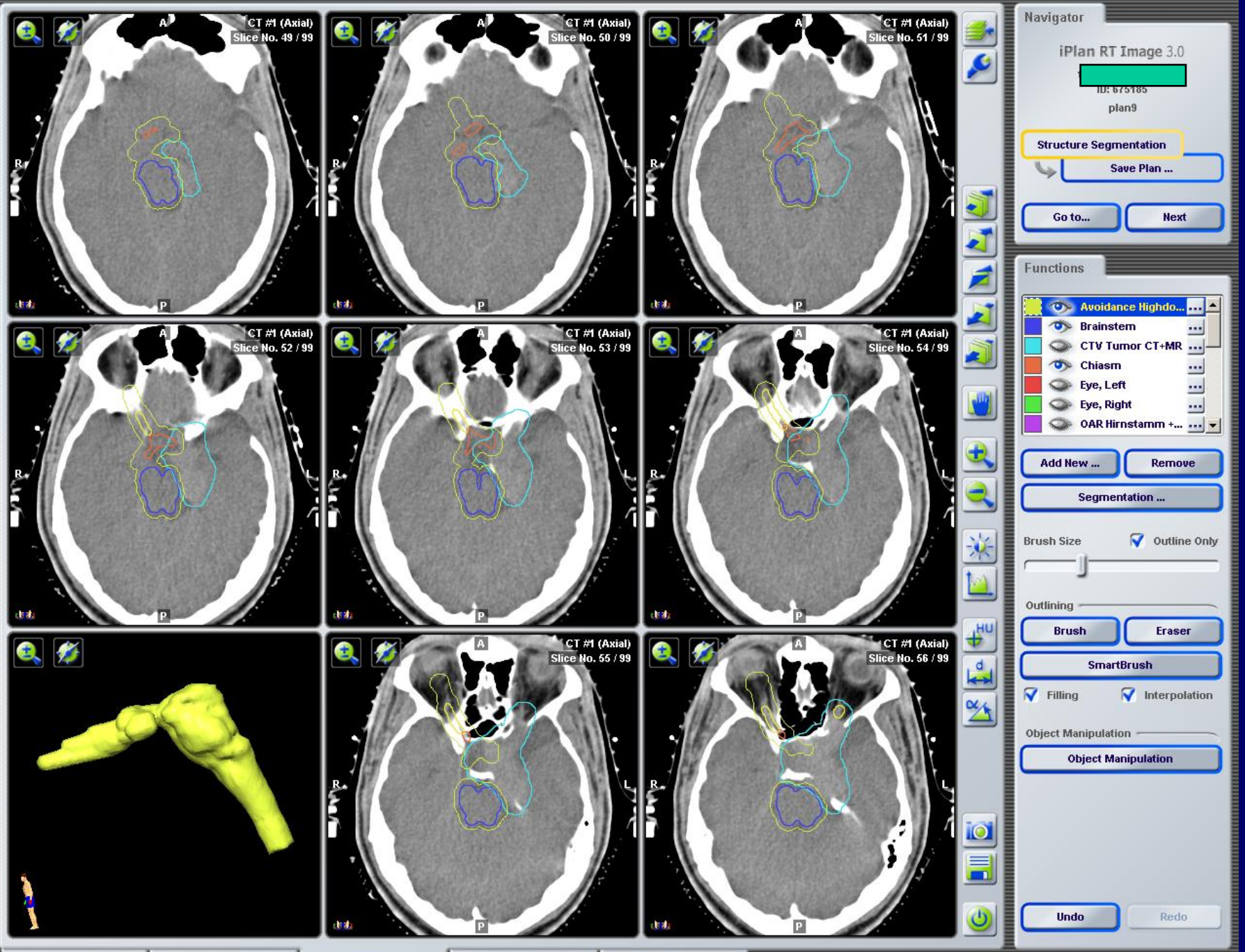
New Object

Name: Avoidance Highdose

Volume: 78.646 cm³

Generate

OK | Cancel



Navigator

iPlan RT Image 3.0

ID: 675185

plan9

Structure Segmentation

Save Plan ...

Go to...

Next

Functions

Avoidance Highdo...

Brainstem

CTV Tumor CT+MR

Chiasm

Eye, Left

Eye, Right

OAR Hirnstamm +...

Add New ...

Remove

Segmentation ...

Brush Size

Outline Only

Outlining

Brush

Eraser

SmartBrush

Filling

Interpolation

Object Manipulation

Object Manipulation

Undo

Redo

Overview

4 Slices

8 Slices

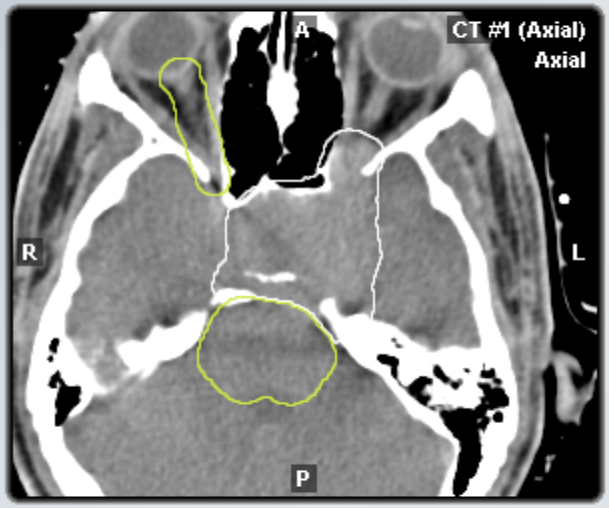
Multiple Sets

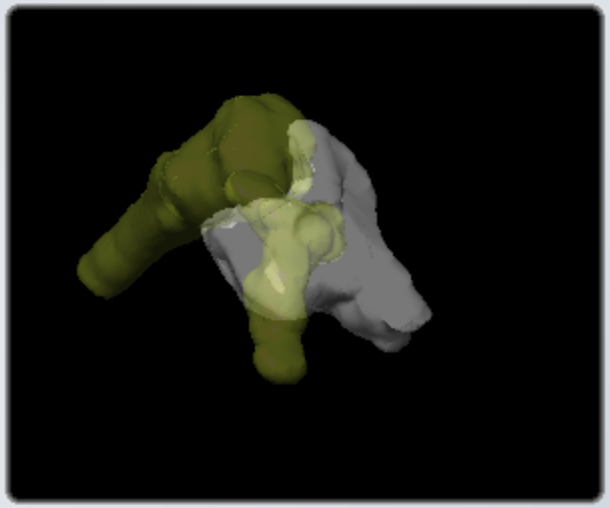
Plan Content

BrainLAB

Morphology | Boolean Operations

Preview





First Operand

- OAR opt.re+Chiasma+5...
- Optic Nerve, Left
- Optic Nerve, Right
- PTV 54 Gy
- PTV 60 Gy
- **PTV mind. 54 Gy** (selected)
- PTV54Gy-avoid.OAR

Second Operand

- **Avoidance Highdose** (selected)
- Brainstem
- CTV Tumor CT+MR
- Chiasm
- Eye, Left
- Eye, Right
- OAR Hirnstamm +3mm

Boolean Merge Mode

( ) Union ( ) Intersection (•) Subtraction

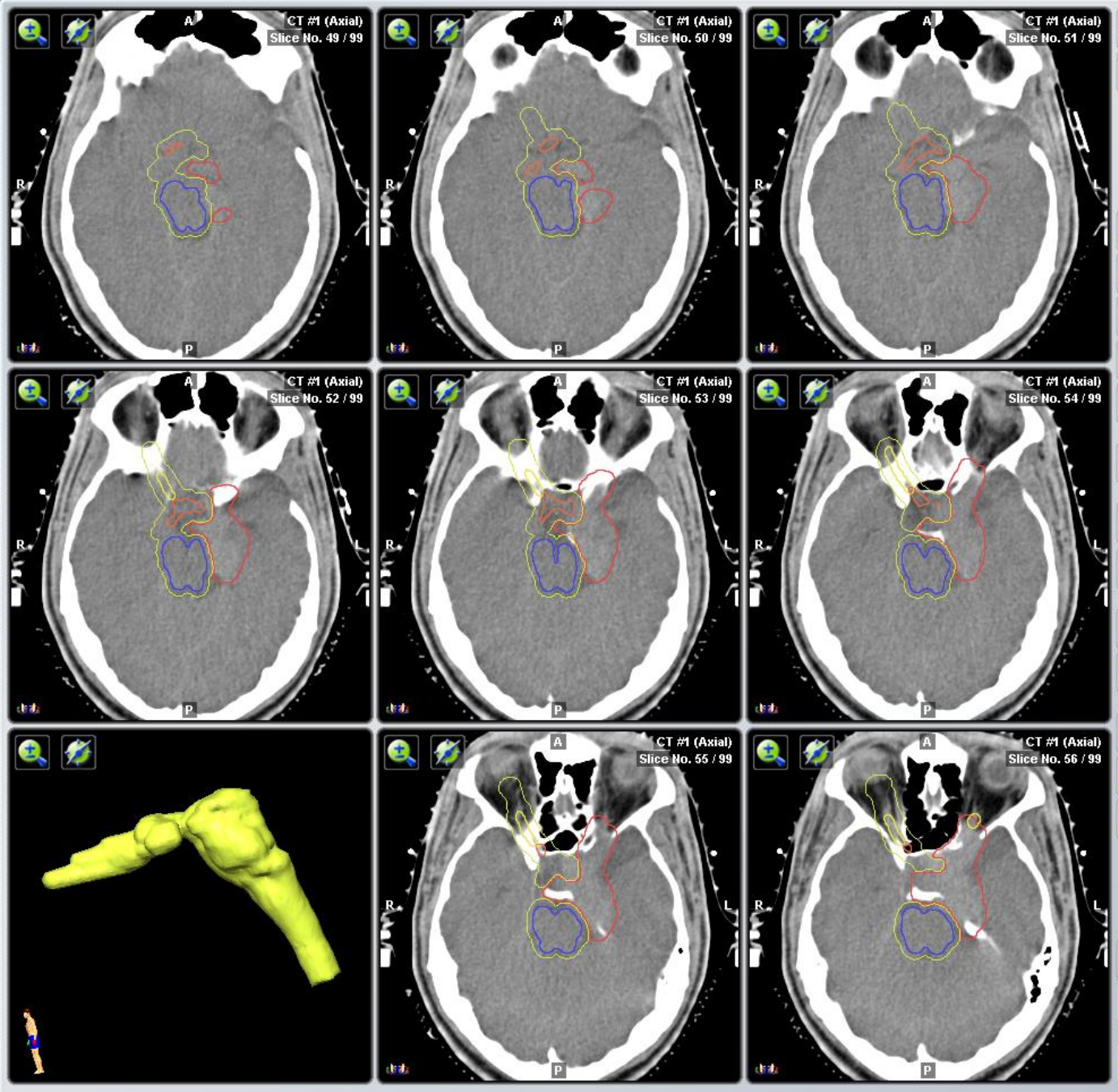
New Object

Name: PTV 60 Gy

Volume: 62.251 cm³

Generate

OK | Cancel



Navigator

iPlan RT Image 3.0

ID: 675185

plan9

Structure Segmentation

Save Plan ...

Go to... Next

Functions

- Optic Nerve, Left
- Optic Nerve, Right
- Outer Contour
- PTV 54 Gy
- PTV 60 Gy
- PTV mind. 54 Gy
- PTV54Gy-avoid.OAR

Add New ... Remove

Segmentation ...

Brush Size Outline Only

Outlining

Brush Eraser

SmartBrush

Filling Interpolation

Object Manipulation

Object Manipulation

Undo Redo

Overview | 4 Slices | 8 Slices | Multiple Sets | Plan Content

BrainLAB

Biologische Überlegungen zur IMRT bei Schädelbasistumoren

- Modifikation der Fraktionsdosis und Behandlungszeit
  - Akzellerierte Bestrahlung im Hochdosisvolumen
  - Niedrigerere Dosisintensität/Fraktionsdosis an Normalgeweben (opt. System/Hirnstamm)
- Biologische Modellierung bei BPL
  - TCP
  - NTCP
- Protrahierung der Dosisapplikation
- Höhere Ganzkörperdosis (mehr MU, Streustrahlung)

Höheres Risiko für Sekundärtumore nach IMRT

Dörr 2002/Gray 1957

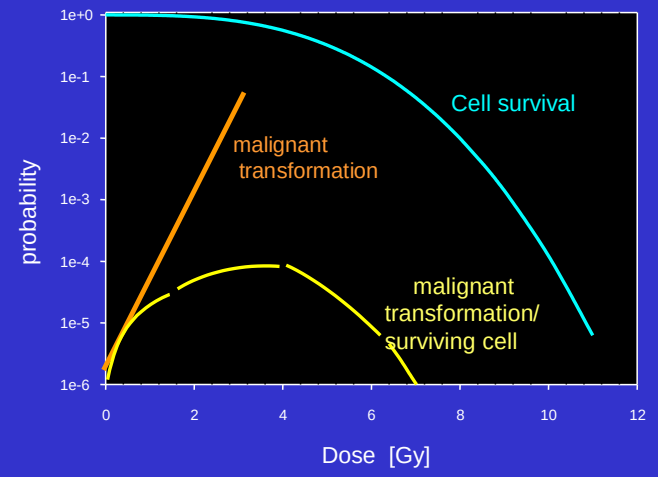


Table 1. Lifetime probabilities of developing fatal secondary malignancies by organ site

Organ	Probability of fatal cancer (%/Sv)
Bladder	0.30
Bone marrow	0.50
Bone surface	0.05
Breast	0.20
Esophagus	0.30
Colon	0.85*
Liver	0.15
Lung	0.85*
Ovary	0.10
Skin	0.02
Stomach	1.10*
Thyroid	0.08
Remainder of body	0.50
Total	5.00

* Prime site for developing a second malignancy.

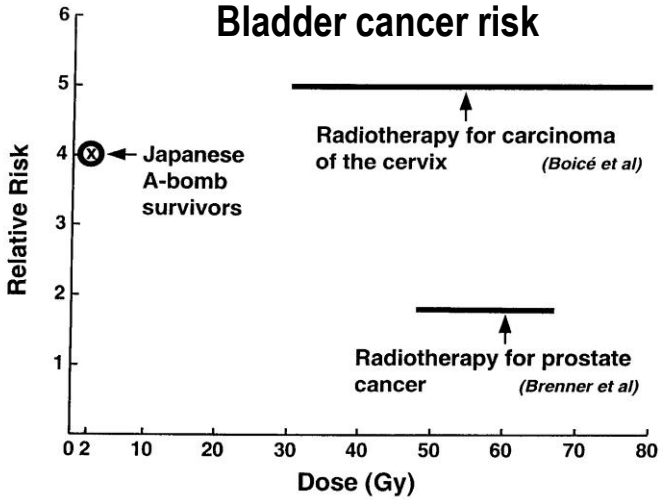


Table 3. Estimated risk of fatal radiation-induced malignancies after RT for prostate cancer (%/Sv)

Hall and Wuu (4)	
Conventional 6 MV	1.5
IMRT 6 MV	3.0
Kry *et al.* (5)	
Conventional 18-MV Varian	1.7
IMRT 6-MV Varian	2.9
Siemens	3.7
IMRT 10-MV Varian	2.1
IMRT 15-MV Varian	3.4
Siemens	4.0
IMRT 18-MV Varian	5.1

Abbreviations: IMRT = intensity-modulated radiation therapy; MV = megavoltage; RT = radiation therapy.

Hall: Int. J. Radiation Oncology Biol. Phys. 65(2006);1–7

preferential tumour induction
- within low dose volume (field margin)
- with long latent times (10-20 y)

increase in low dose normal tissue volume:
IMRT
multiple field techniques

??? increased tumour incidence ???

sufficient follow-up
documentation and reporting of normal tissue effects

Danke für Ihre Aufmerksamkeit