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Christian-Albrechts-Universität zu Kiel
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seit 350 Jahren ganz weit oben

Qualitäts- und Dokumentationsanforderungen für die intrakranielle Stereotaktische Strahlentherapie

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Hintergrund Inhomogener Dosisverteilungen

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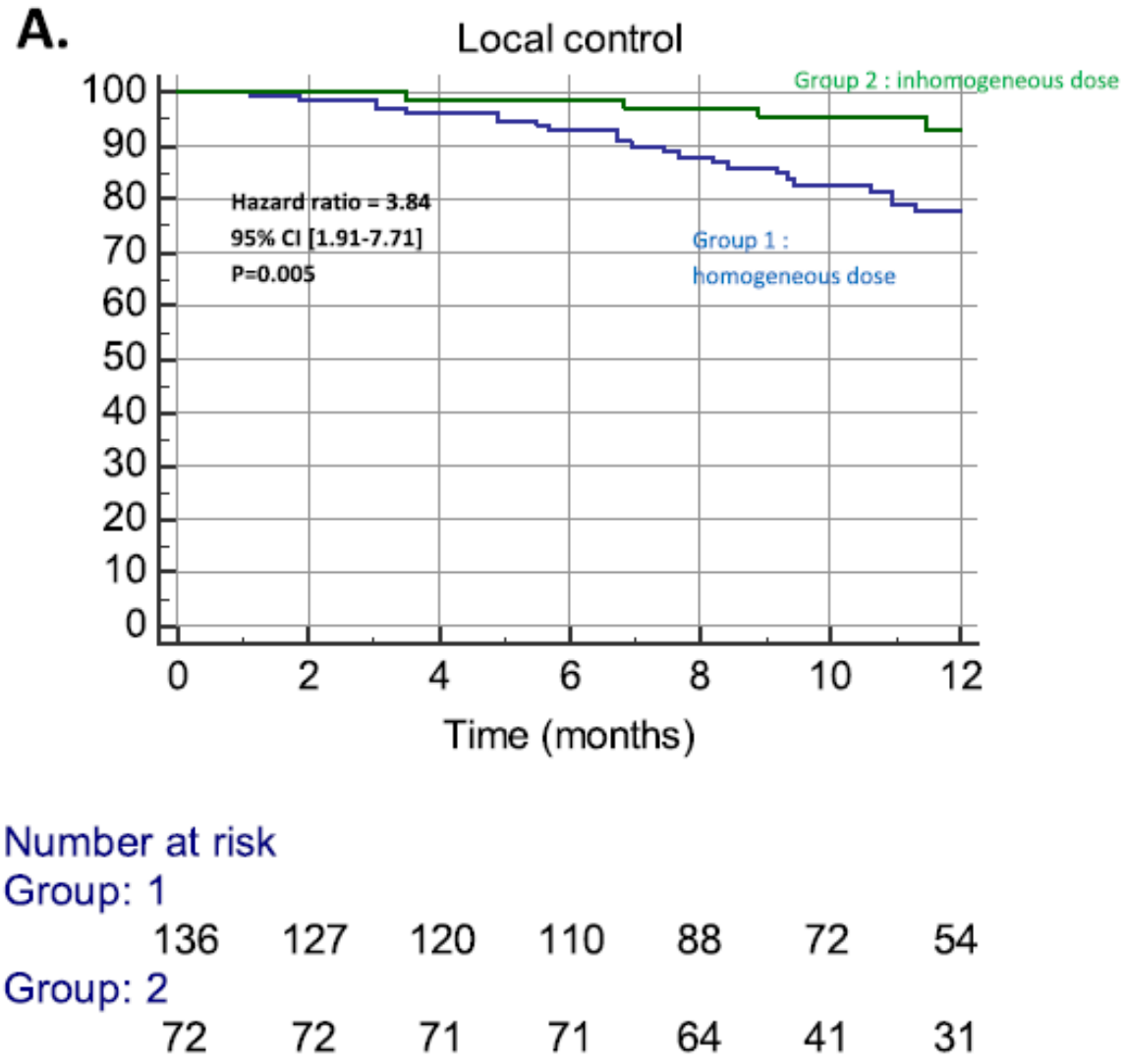
Klinisch-Biologische Überlegungen

- → Deutliche Evidenz für Hirn-Metastasen
  - ❖ Prädiktoren für bessere Lokalkontrolle:
    - ➢ Tumorgröße
    - ➢ Inhomogene Dosisverteilung
  - ❖ Prädiktoren für weniger Radionekrose
    - ➢ Geringe Anzahl an Metastasen
    - ➢ Inhomogene Dosisverteilung

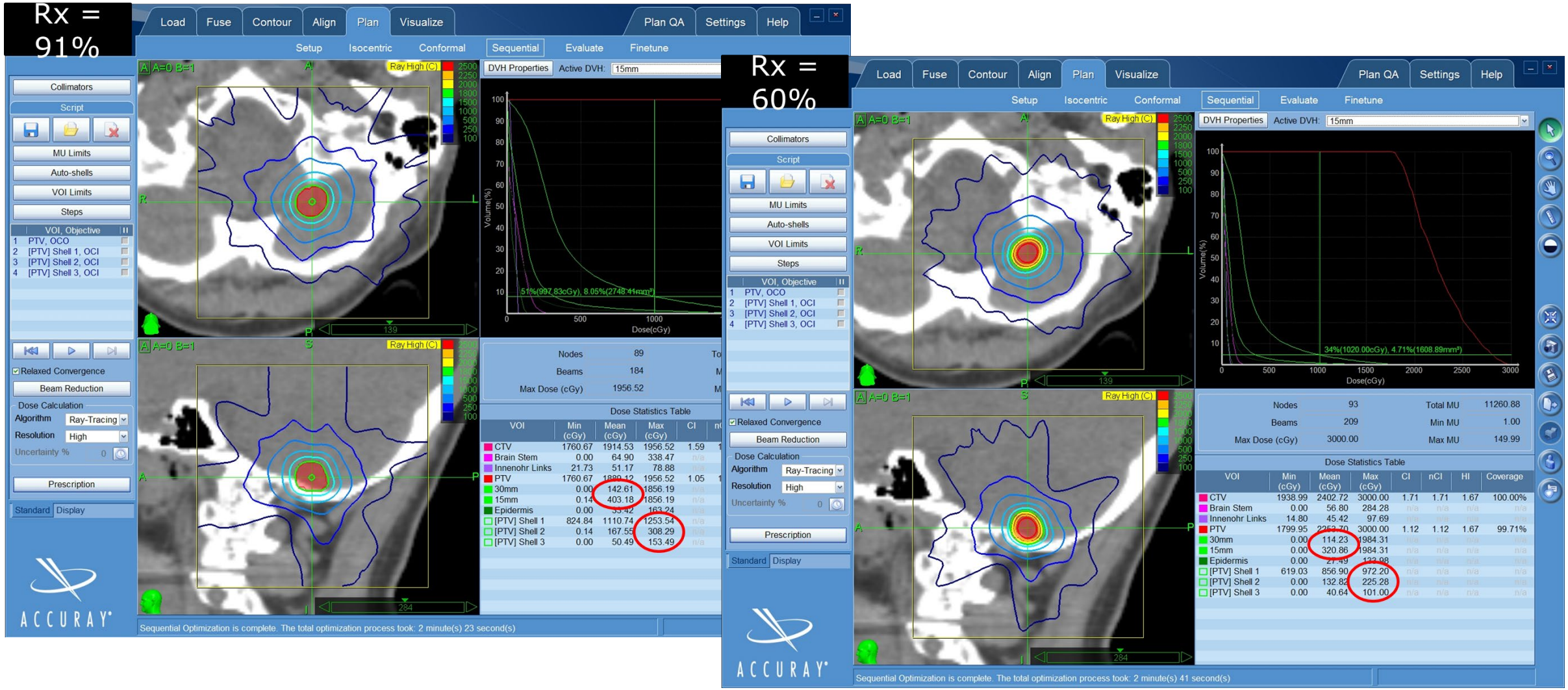
Table 2
Dosimetric parameters.

	Group 1		Group 2
	N = 91 Median (range)	%	*N* = 43 Median (range)
$D_{98\%}$	23.1 Gy (21–23.1)		23.3 Gy (21–23.8)
$D_{2\%}$	24.8 (22.5–25.2)		32.9 (29.8–33.2)
$D_{50\%}$	24.2 (21.2–25.4)		28.1 (27.7–29.8)
$V_{5Gy\ (brain)}$	105.9 (43.2–184.8)		104.3 (42.4–172.5)
$V_{10Gy\ (brain)}$	9.63 (4.83–29.1)		9.07 (4.42–24.51)
$V_{12Gy\ (brain)}$	3.22 (0.45–9.31)		2.71 (0.15–6.21)
$V_{21Gy\ (brain)}$	0.83 (0–2.42)		0.79 (0–2.31)
Target coverage	99.0 (95.4–100)		98.9 (95.3–100)
Conformity Index	1.33 (1.05–1.62)		1.32 (1.06–1.61)
SRT dose			
• 23.1 Gy in 3 fractions	101/136	81.7	59/72
• 21 Gy in 3 fractions	25/136	18.3	13/72



Hintergrund Inhomogener Dosisverteilungen

→ Physikalische Überlegungen



Qualitätsanforderungen für die SRS/FSRT

Strahlenther Onkol
https://doi.org/10.1007/s00066-020-01603-1

CONSENSUS STATEMENT

Definition and quality requirements for stereotactic radiotherapy: consensus statement from the DEGRO/DGMP Working Group Stereotactic Radiotherapy and Radiosurgery

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Stereotactic Radiosurgery (SRS):

Intracranial malignant or benign tumors and functional or vascular disorders with one single irradiation fraction

Fractionated Stereotactic Radiotherapy (FSRT):

Intracranial malignant or benign tumors and functional or vascular disorders

Stereotactic Body Radiotherapy (SBRT):

Extracranial malignant or benign tumors and functional or vascular disorders

Strahlenther Onkol
https://doi.org/10.1007/s00066-020-01583-2

REVIEW ARTICLE

Technological quality requirements for stereotactic radiotherapy

Expert review group consensus from the DGMP Working Group for Physics and Technology in Stereotactic Radiotherapy

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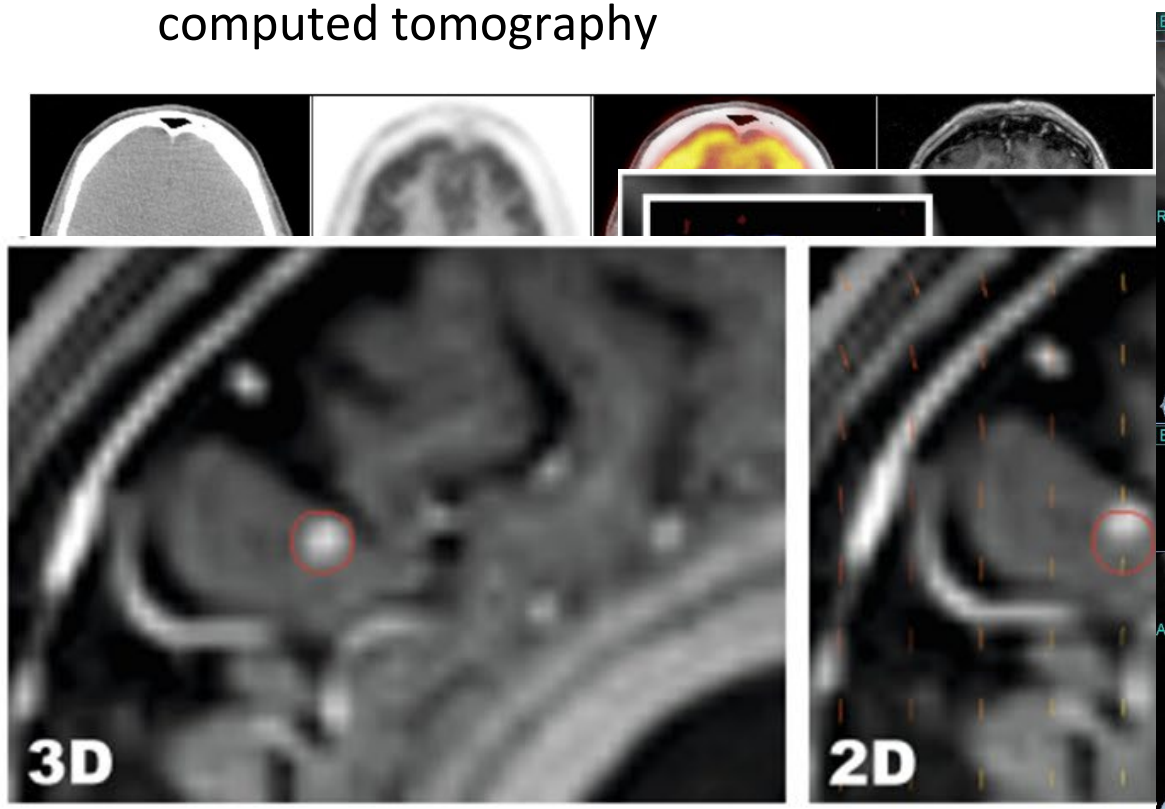
Stereotactic radiosurgery for treatment of brain metastases

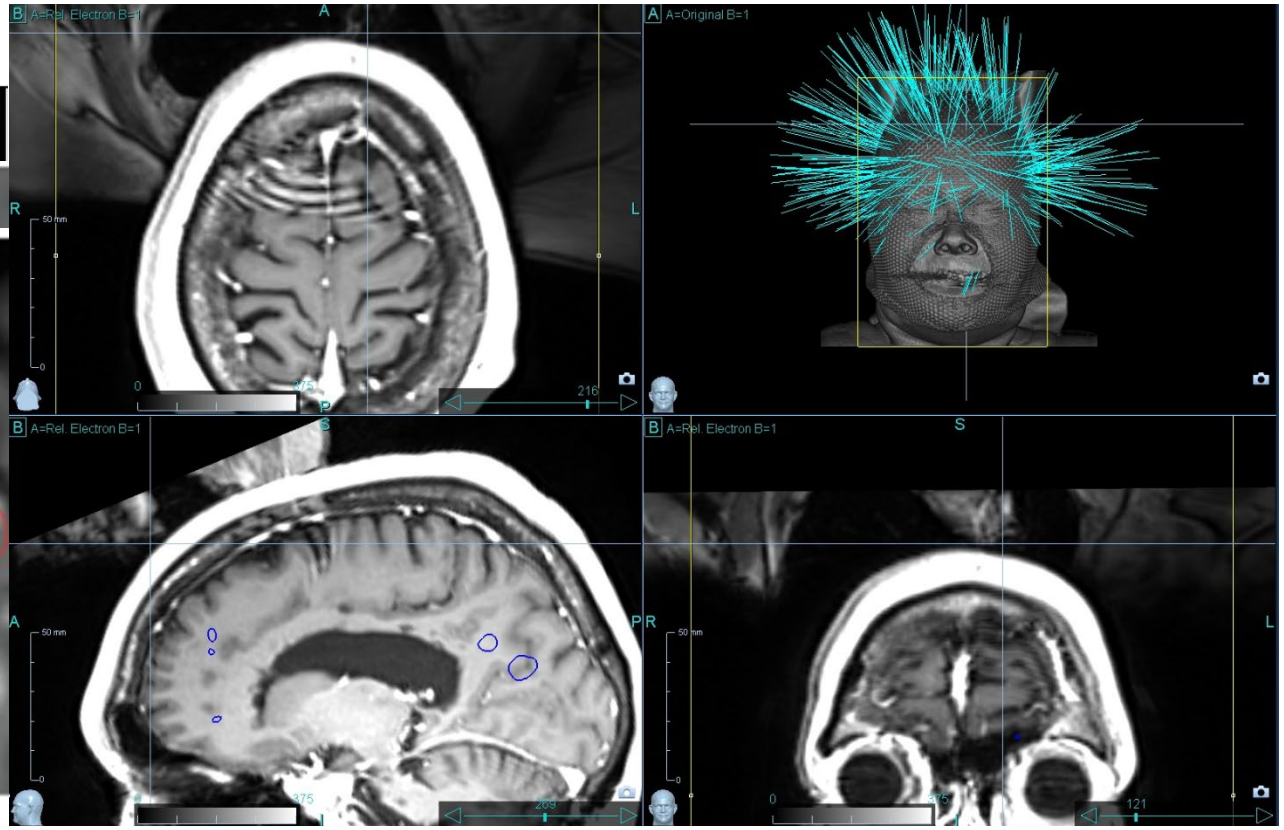
A report of the DEGRO Working Group on Stereotactic Radiotherapy

Qualitätsanforderungen für die SRS/FSRT

Imaging for target volume definition

- The target volume and all organs-at-risk are defined using **organ-specific imaging modalities** and standardized imaging protocols dedicated for stereotactic radiotherapy procedures
- The use of secondary imaging requires **accurate** registration with the **thin-slice** planning computed tomography





Source: Paulson ES, Crijns SP, Keller BM et al (2016) Consensus opinion on MRI simulation for external beam radiation treatment planning. Radiother Oncol 121(2):187–192
Buchbender et al, Oncologic PET/MRI, Part 1: Tumors of the Brain, Head and Neck, Chest, Abdomen, and Pelvis, Journal of Nuclear Medicine 2012

Qualitätsanforderungen für die SRS/FSRT

Patient positioning and target volume localization

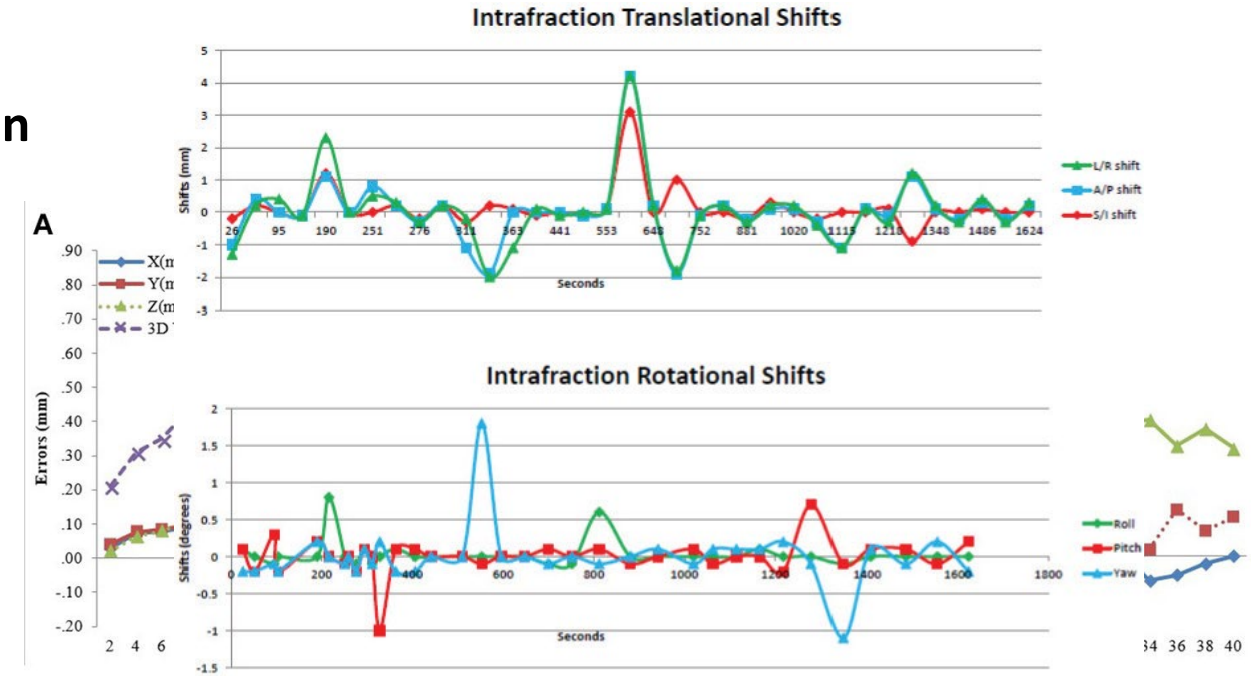
Daily in-room image-guidance and online correction of target position errors using **on-board CT**, supplementary **in-room CT** or **stereoscopic X-ray** is required:

- SRS: Invasive fixation using a stereotactic head frame can be used alternatively to image guidance
- SRS and FSRT: Non-invasive fixation of the patient's head is combined with image-guidance

Motion management

Systematic assessment and **consistent consideration** of periodic and non-periodic target motion during:

- → Imaging for treatment planning;
- → Target volume definition;
- → Beam-delivery technique planning;
- → Dose simulation;
- → Target volume localization & repositioning; and
- → **Dose application**



Source: Kataria T, et al. Analysis of intrafraction motion in CyberKnife-based stereotaxy using mask based immobilization and 6D-skull tracking. J Radiosurg SBRT. 2016;4(3):203-212. Kang CL, et al. Comparison of Skull Motions in Six Degrees of Freedom Between Two Head Supports During Frameless Radiosurgery by CyberKnife. Front Oncol. 2018 4;8:359.

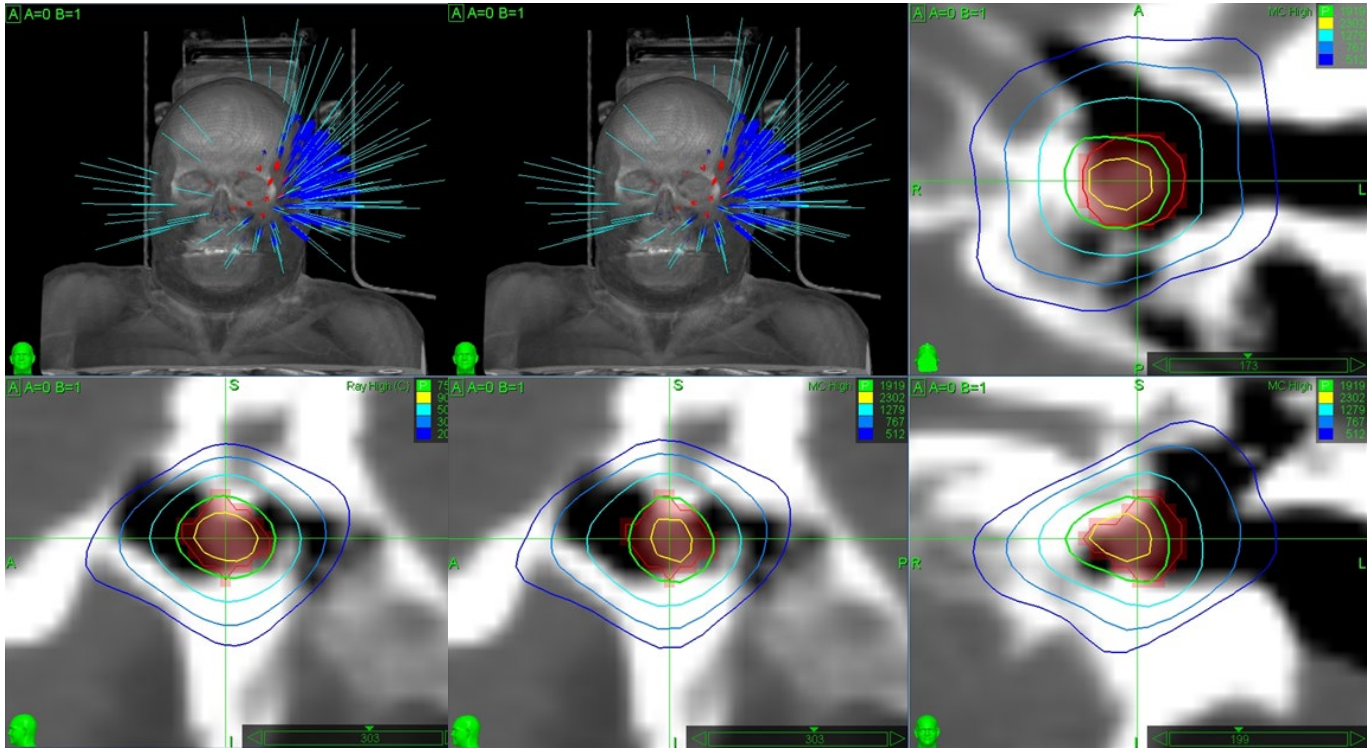
Qualitätsanforderungen für die SRS/FSRT

Collimation of the irradiation and beam directions

For the respective treatment modalities, collimation and beam direction requires the following characteristics: **SRS** with multileaf collimator (MLC) with leaf width **5mm** or cylindrical collimators of equivalent size, […], and used with systems allowing **non-coplanar beam directions**. **FSRT** with MLC with leaf width **6.5mm** or cylindrical collimators of equivalent size, both at normal treatment distance.

Dose calculation

For stereotactic radiotherapy in areas with large **density inhomogeneities** the use of a dose calculation algorithm that takes into account lateral electron transport to **correct for density inhomogeneities** is required. The maximum grid size for dose calculation should be 1–2mm according to the target lesion dimensions and the image resolution for target definition



Torizuka D, et al. Dosimetric comparison among dynamic conformal arc therapy, coplanar and non-coplanar volumetric modulated arc therapy for single brain metastasis. J Radiat Res. 2021:rrab092.

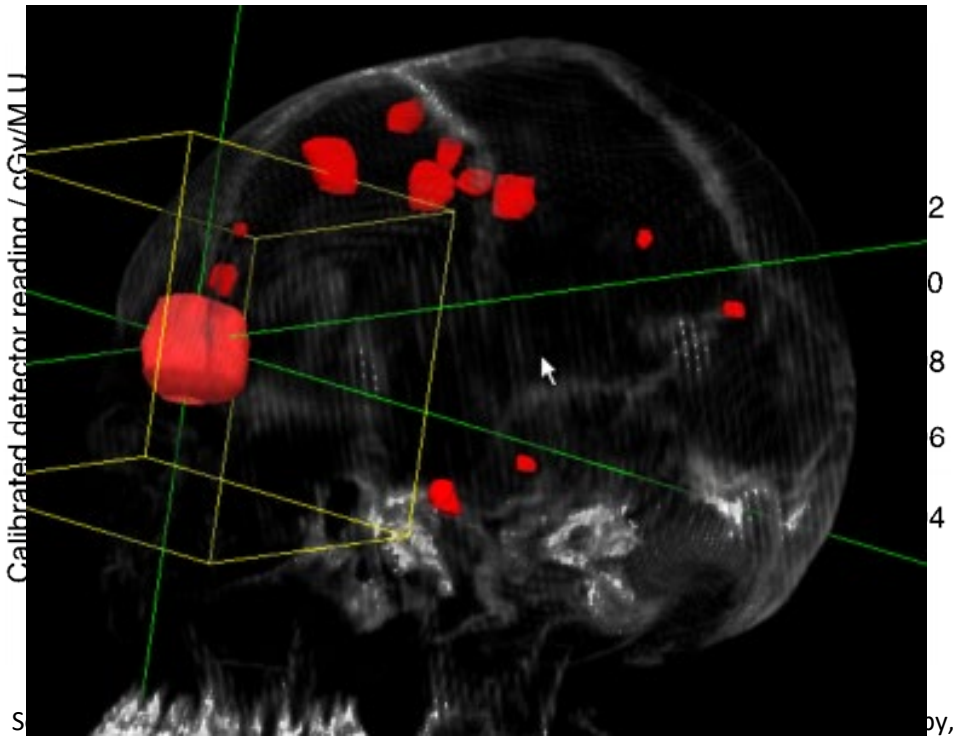
Qualitätsanforderungen für die SRS/FSRT

Treatment unit accuracy

A geometric accuracy with three-dimensional spatial dose placement in **system-specific end-to-end tests** requires inaccuracies of at maximum: **1mm for SRS**, **1.25mm for FSRT** and SBRT in non-moving phantoms, and 1.5mm for SBRT in moving phantoms. However, for **FSRT** and SBRT **close** to radiation-sensitive critical structures the **same** geometric accuracy requirement as for SRS is recommended. A **dosimetric accuracy** with point-based plan-to-measurement differences of **maximum 3%** within a target volume of more than or equal to 2cc [..]

Dedicated quality assurance measures

- Small field dosimetry for commissioning.
- System-specific end-to-end testing for both static and moving target volumes.
- Regular check of the geometric and dosimetric accuracy according to system-specific guidelines.
- Day-to-day quality control of the consistency of the stereotactic frame and/or the image-guidance system isocenter with the treatment beam isocenter.



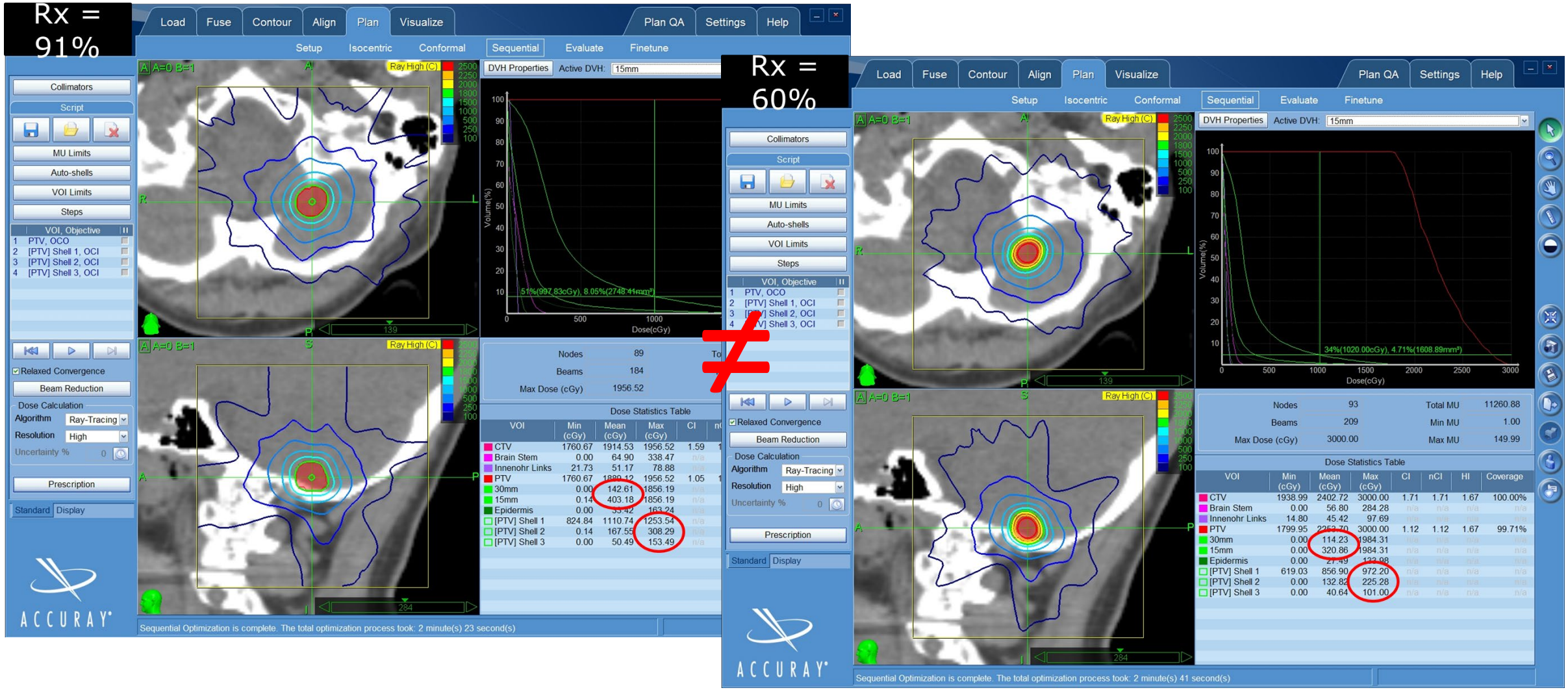
International Code of Practice for Reference and Relative Dose Determination

Qualitätsanforderungen für die SRS/FSRT

Process quality requirements

- Written **standard operating procedures** for all stereotactic radiotherapy relevant process steps are required
- **Interdisciplinary** discussions on the indication for stereotactic radiotherapy are required
- A **trained** multiprofessional stereotactic radiotherapy project team (radio-oncology, medical physics, radiation therapists) for the implementation and application of SRS/FSRT/SBRT is required
- **Sufficient experience** in stereotactic radiotherapy with **≥ 20 patients** treated each year with SRS, FSRT and SBRT (experiences gained in SRS can be transferred to FSRT) is required
- **Prescribing, recording and reporting** each SRS/FSRT/SBRT treatment procedure according to international guidelines and standards is required (ICRU91)

Dokumentationsanforderungen für die SRS/FSRT



Dokumentationsanforderungen für die SRS/FSRT

Level 2:
Advanced Techniques

DVHs calculated
PTV: $D_{50\%}$, $D_{near\text{-}min}$, $D_{near\text{-}max}$
GTV/CTV/ITV: $D_{50\%}$ must for Lung
OAR/PRV: Vol, D_{mean}, V_D, $D_{2\%}$
Dose Homogeneity and
Conformity and Gradient Index

ICRU Report 91

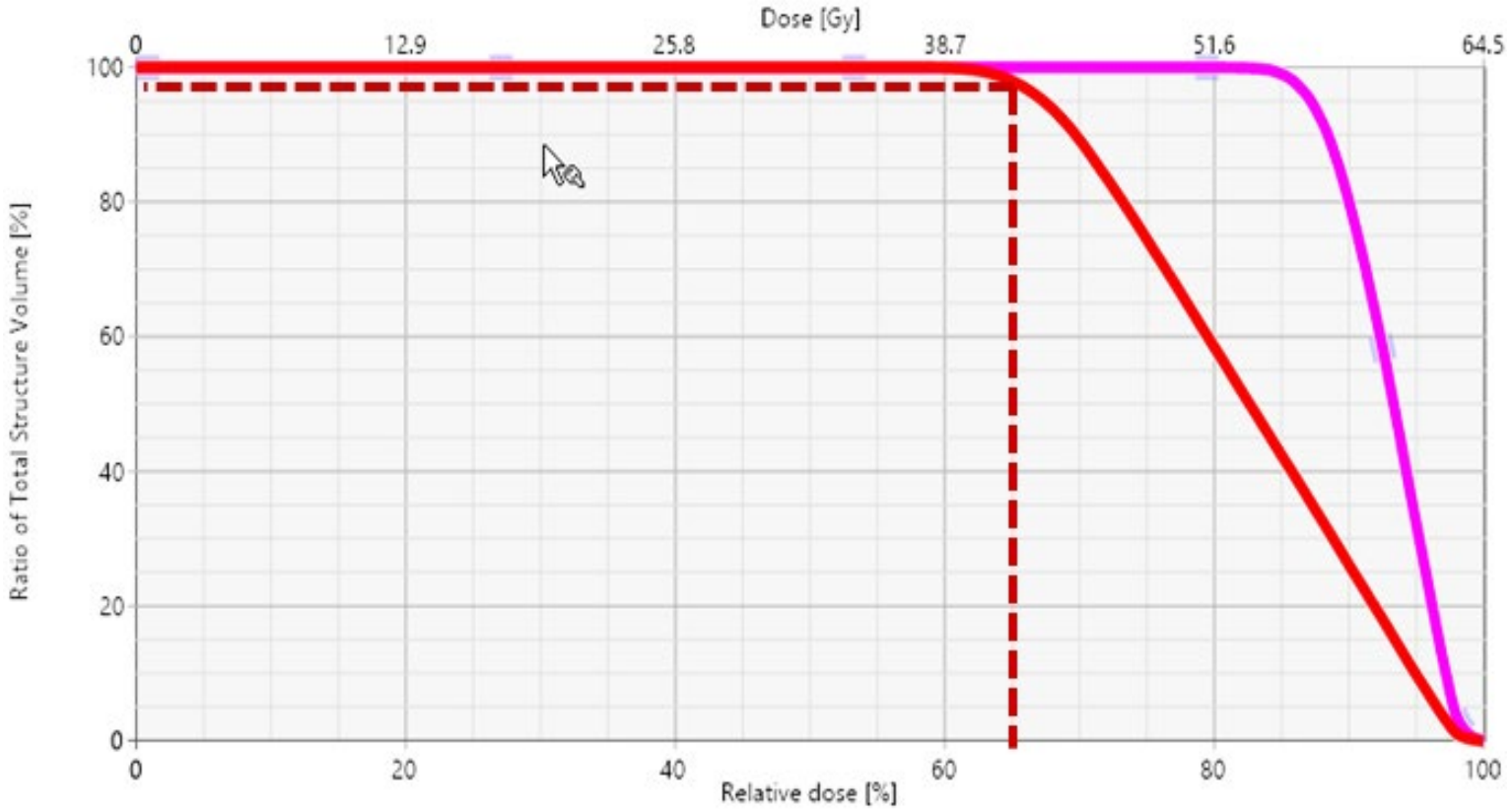
→ Verschreibung auf „Surrounding Isodose Surface“

→ Level 2 Reporting für Margins, Min/Max/Median Dose …

ICRU Report 91 on Prescribing, Recording, and Reporting of Stereotactic Treatments with Small Photon Beams

A Statement from the DEGRO / DGMP Working Group Stereotactic Radiotherapy and Radiosurgery

Lotte Wilke (PhD)[1*], Nicolaus Andratschke (MD)[1], Oliver Blanck (PhD)[2], Thomas B. Brunner (MD)[3], Stephanie Combs (MD)[4], Anca-Ligia Grosu (MD)[5], Christos Moustakis (PhD)[6], Daniela Schmitt (PhD)[7], Wolfgang Baus (PhD)[8], Matthias Guckenberger (MD)[1]



Dokumentationsanforderungen für die SRS/FSRT

ICRU Report 91: Beispiel SRS einer Hirnmetastase

VOI List

VOI	Volume (cm³)	Min (cGy)	Mean (cGy)	Max (cGy)	CI	nCI	HI	Coverage %	Beam Inter.
GTV1	0.58	1912	2606	3333	1.07	1.08	1.67	98.45	n/a
Auge Links	10.80	11	13	14	n/a	n/a	n/a	n/a	Never
Auge Rechts	10.77	11	13	19	n/a	n/a	n/a	n/a	Never
Linse Links	0.17	12	12	13	n/a	n/a	n/a	n/a	Never
Linse Rechts	0.16	12	13	13	n/a	n/a	n/a	n/a	Never
Hirnstamm	23.45	10	11	22	n/a	n/a	n/a	n/a	Never
Ganzhirn	1419.35	10	36	3333	n/a	n/a	n/a	n/a	Allowed
Chiasma Opticum	0.31	12	12	16	n/a	n/a	n/a	n/a	Never
Sehnerv Links	0.85	11	12	13	n/a	n/a	n/a	n/a	Never
Sehnerv Rechts	0.76	12	12	14	n/a	n/a	n/a	n/a	Never
Hypophyse	0.68	11	12	16	n/a	n/a	n/a	n/a	Never
Innenohr Links	1.26	11	11	12	n/a	n/a	n/a	n/a	Never
Innenohr Rechts	1.26	11	11	12	n/a	n/a	n/a	n/a	Never
PreSRS_0621	0.43	20	24	28	n/a	n/a	n/a	n/a	Never
PTV1	0.58	1912	2606	3333	1.07	1.08	1.67	98.45	n/a
Boost	0.11	2933	3164	3333	5.58	5.58	1.67	100.00	n/a
Block	65.10	8	9	10	n/a	n/a	n/a	n/a	Never
* Epidermis	1298.92	8	15	302	n/a	n/a	n/a	n/a	Allowed
* Body	5896.18	8	20	3333	n/a	n/a	n/a	n/a	Allowed
[PTV1] Shell 3	7.22	32	79	193	0.00	0.00	0.00	0.00	Allowed
[PTV1] Shell 2	3.09	48	158	257	0.00	0.00	0.00	0.00	Allowed
[PTV1] Shell 1	0.61	443	744	849	0.00	0.00	0.00	0.00	Allowed
All Target Regions	n/a	1912	2606	3333	1.07	1.08	1.67	98.45	n/a
All Critical Regions	n/a	8	26	3333	n/a	n/a	n/a	n/a	n/a
Soft Tissue	n/a	8	15	1143	n/a	n/a	n/a	n/a	n/a

Zusammenfassung

- Klare **Qualitätskriterien** für die **GESAMTE** Behandlungskette der Stereotaktischen Strahlentherapie (SRS ≤ FSRT ≤ SBRT) durch DEGRO und DGMP **etabliert**

- Diese werden **TEIL** der überarbeiteten **DIN Norm** Stereotaktische Strahlentherapie (in Arbeit), der **Ärztlichen Stelle Prüfungen** (im engen Austausch) und der **Abrechnung** für die Stereotaktische Radiochirurgie im Rahmen des EBM (Anforderungen nach Vorlage des GBA)

- **Kernmerkmale** der **Qualitätskriterien** für die Stereotaktische Strahlentherapie:
  - Voraussetzungen und Prozessstrukturen (Training, SOPs, etc.)
  - Bildgebung/-registrierung und Konturierung (und Unsicherheiten)
  - Technische und klinische Genauigkeiten (und deren Messung)
  - Dokumentation und Nachsorge (1 x 20 Gy ≠? 1 x 20 Gy)

- **Vision: Innovative Radioonkologie im Team – präzise, personalisiert, menschlich**