SCaLPEL Erasmus+
2022 / 2023
online session II

Department of Neurosurgery
Clinical Hospital Centre Zagreb
Medical School, University of Zagreb

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the European Union

Brain Arteriovenous Malformations radiosurgery

Natural history

- approx. 2-4 % annual risk of rupture
- risk higher with previous bleed
- can be associated to AVM size and presentation
- 10 % severe morbidity / mortality

Goal of AVM treatment

- resect or obliterate nidus - prevent (re)bleed
- preserve neurological function
- treat associated seizures (when possible)
- as little damage as possible with treatment

Grading of AVMs

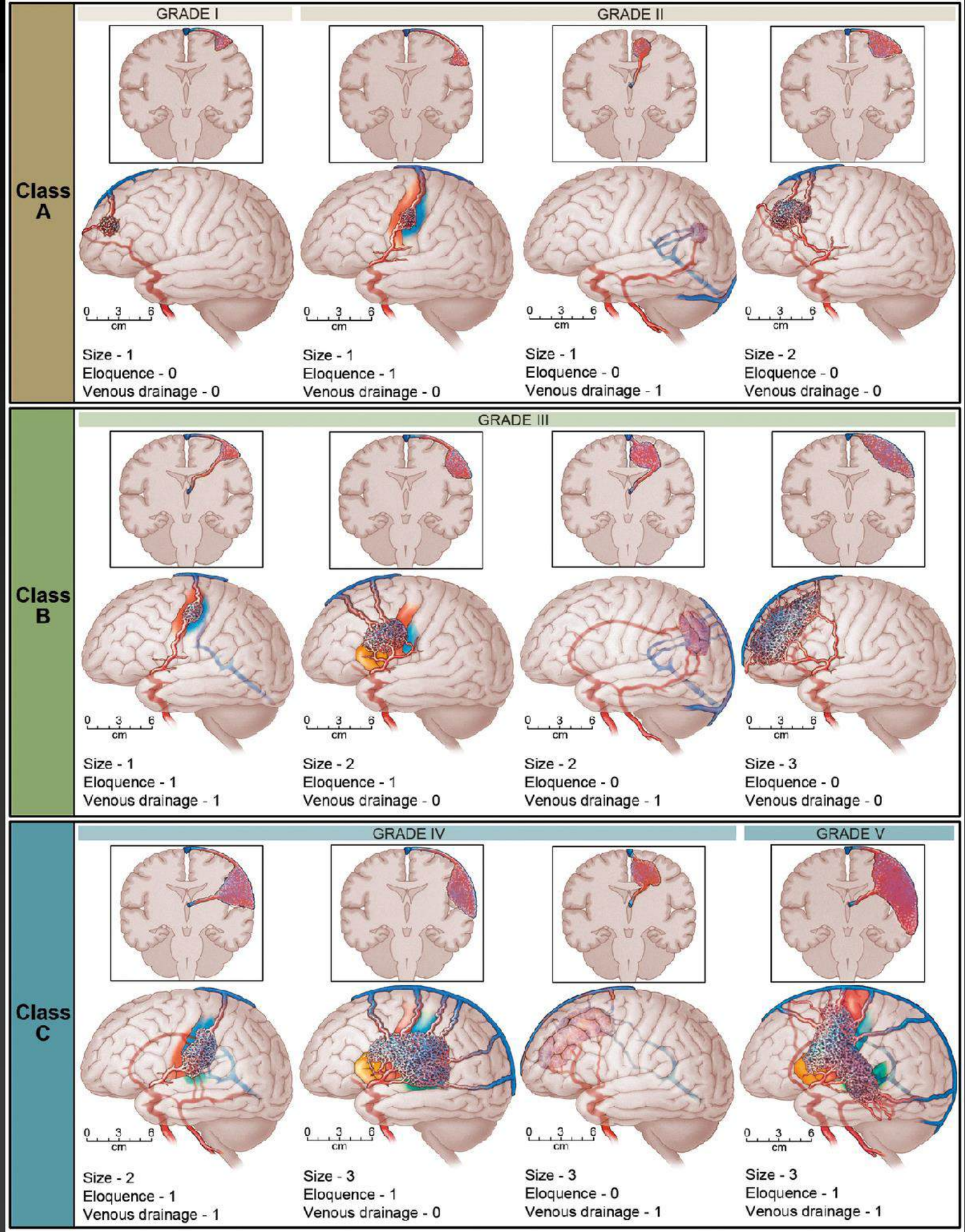
Spetzler - Martin Grading Scale

Characteristic	Number of points assigned
Size of AVM	
Small (<3 cm)	1 point
Medium (3–6 cm)	2 points
Large (>6 cm)	3 points
Location	
Noneloquent site	0 points
Eloquent site*	1 point
Pattern of venous drainage	
Superficial only	0 points
Deep component	1 point

*Sensorimotor, language, visual cortex, hypothalamus, thalamus, internal capsule, brain stem, cerebellar peduncles, or cerebellar nuclei.

Grading of AVMs

Spetzler - Ponce Grading Scale



Grading of AVMs

Supplemented SM Grading Scale

Lawton-Young Grading Scale

Spetzler-Martin grading

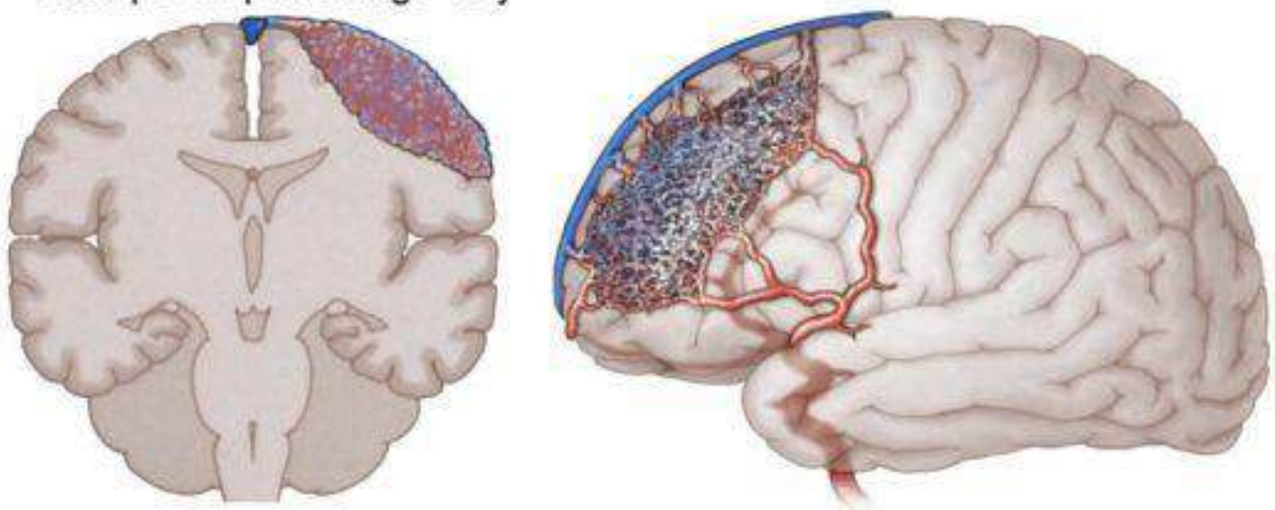
Size:	<3 cm = 1, 3-6 cm = 2, >6 cm = 3	**S** ___
Venous drainage:	superficial = 0, deep = 1	**V** ___
Eloquence:	no = 0, yes = 1	**E** ___

Lawton-Young grading

Age:	<20 y = 1, 20-40 y = 2, >40 y = 3	**A** ___
Bleeding:	yes = 0, no = 1	**B** ___
Compactness:	compact = 0, diffuse = 1	**C** ___

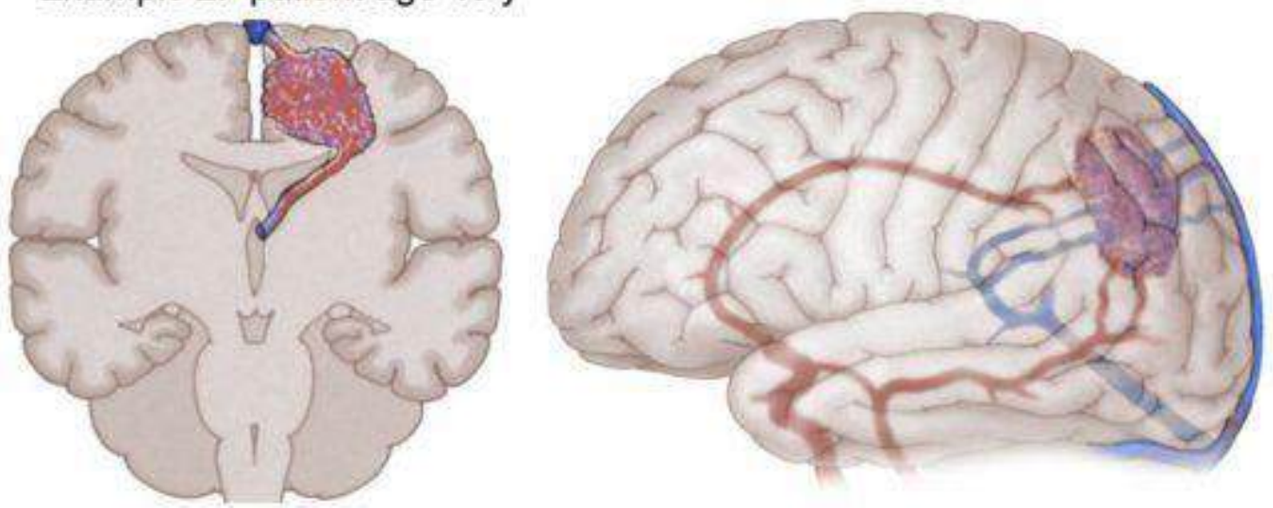
Supplemented Spetzler-Martin grade **Total** ___

Example 1: patient age 17 y



S	3
V	0
E	0
A	1
B	1
C	0
	5

Example 2: patient age 43 y



S	2
V	1
E	0
A	3
B	1
C	0
	7

Grading of AVMs

Virginia Radiosurgery AVM Grading Scale

	Points
Modified Pollock-Flickinger score	Score = (0.1)(volume, mL) + (0.02)(age, y) + (0.5)(location[a])
Virginia Radiosurgery AVM scale	
Volume	
<2 mL	0
2-4 mL	1
>4 mL	2
Eloquent location	1
History of hemorrhage	1
Total	0-4 points

[a] Hemispheric/corpus callosum/cerebellar = 0; basal ganglia/thalamus/brainstem = 1.

Grading of AVMs

Radiosurgery based AVM Scale - *RBAS* (UPMC SRS)

Characteristic		Coefficient
Volume		0.1
Patient age		0.02
Location[b]	frontal, temporal = 0 parietal, occipital, intraventricular, corpus callosum, cerebellar = 1 basal ganglia, thalamic, brainstem = 2	0.3

[a] RBGS = (0.1) (volume) + (0.02) (patient age) + (0.3) (location).

[b] When an AVM involves multiple sites, fractional values are used according to the number of sites (0.5 for two sites, 0.33 for three sites).

Treatment

Treatment

ruptured bAVM

Treatment

ruptured bAVM

treatment

Treatment

unruptured bAVM

??

Treatment

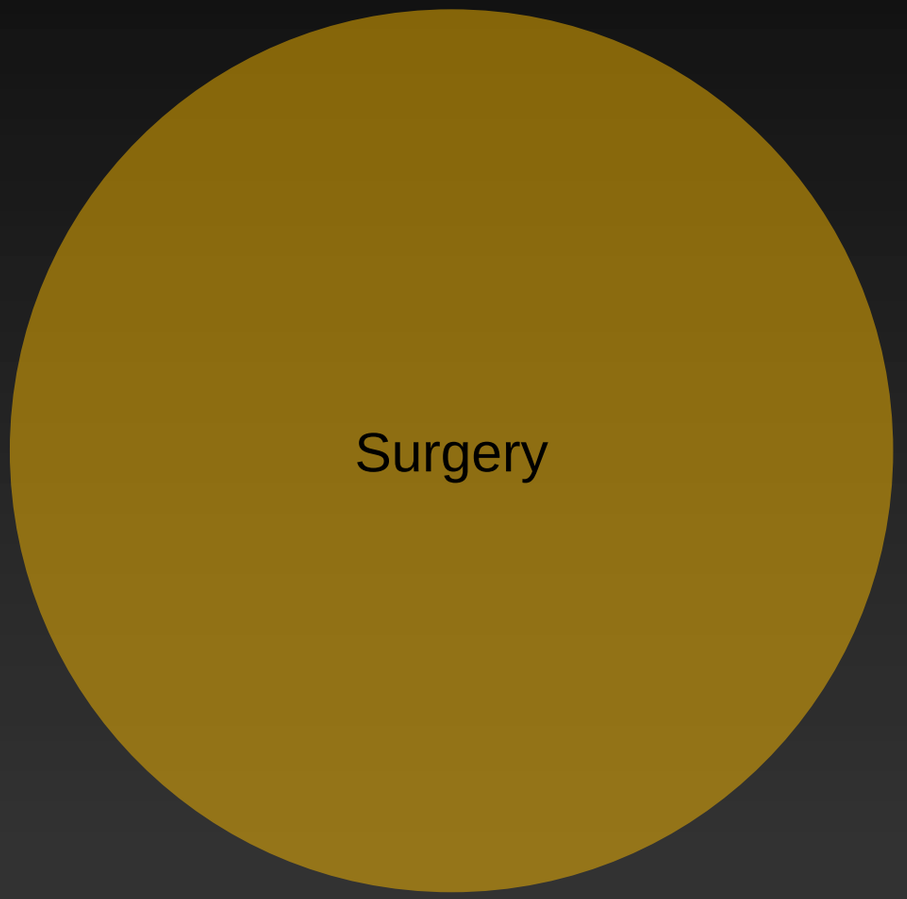
unruptured bAVM

?? (ARUBA)

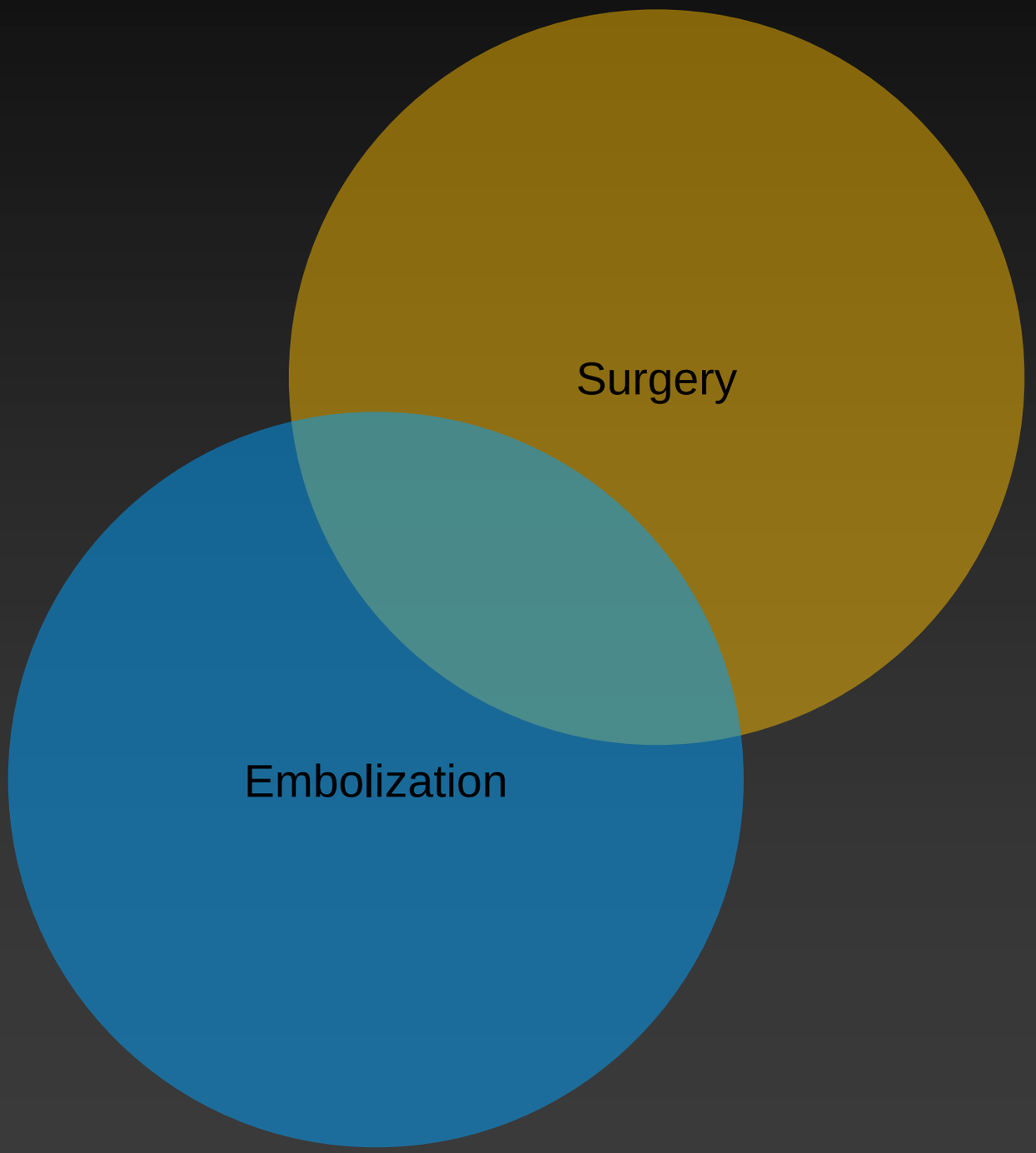
Treatment

Conservative

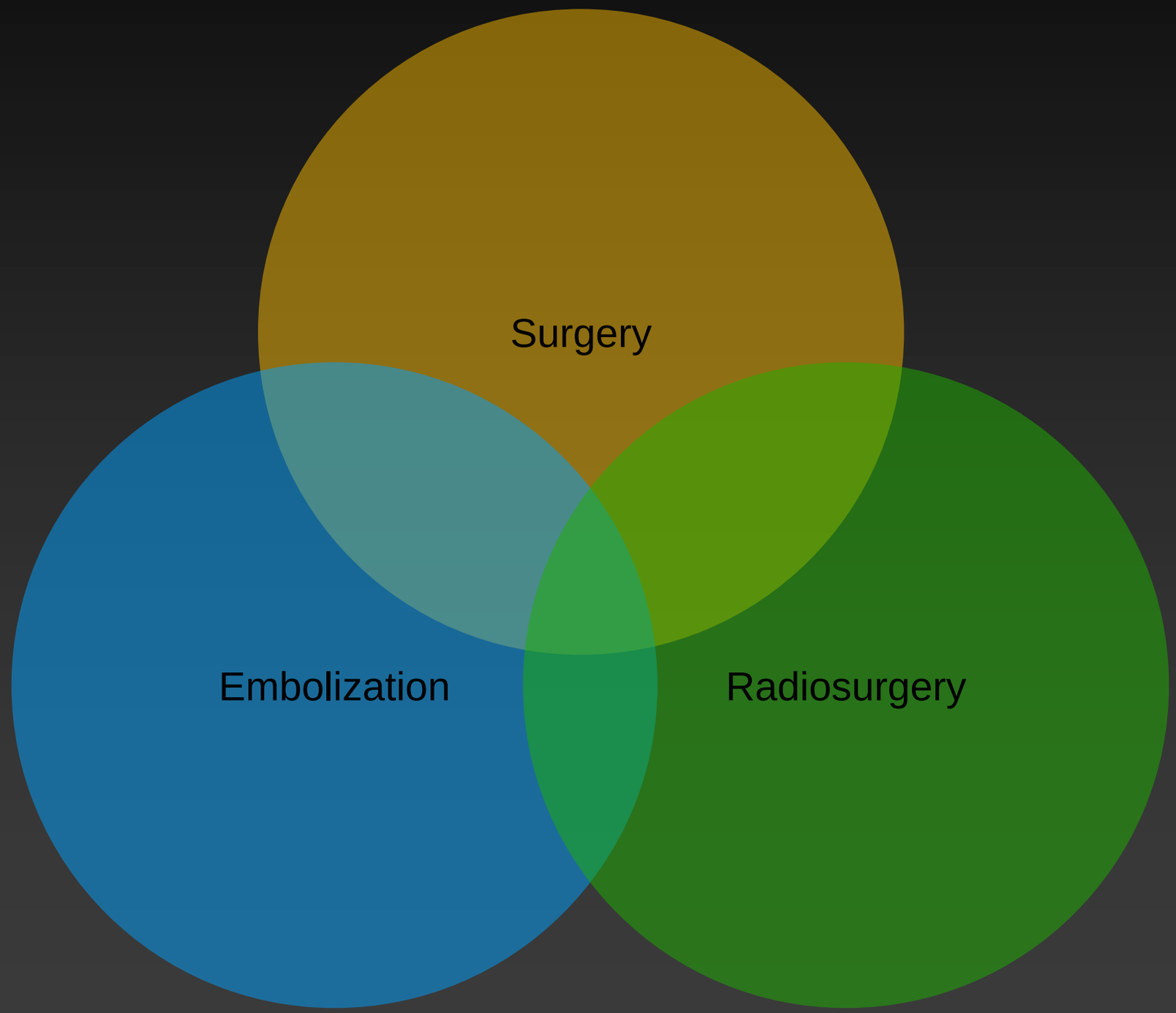
Treatment



Treatment



Treatment



Treatment

Radiosurgery

Radiosurgery for bAVMS

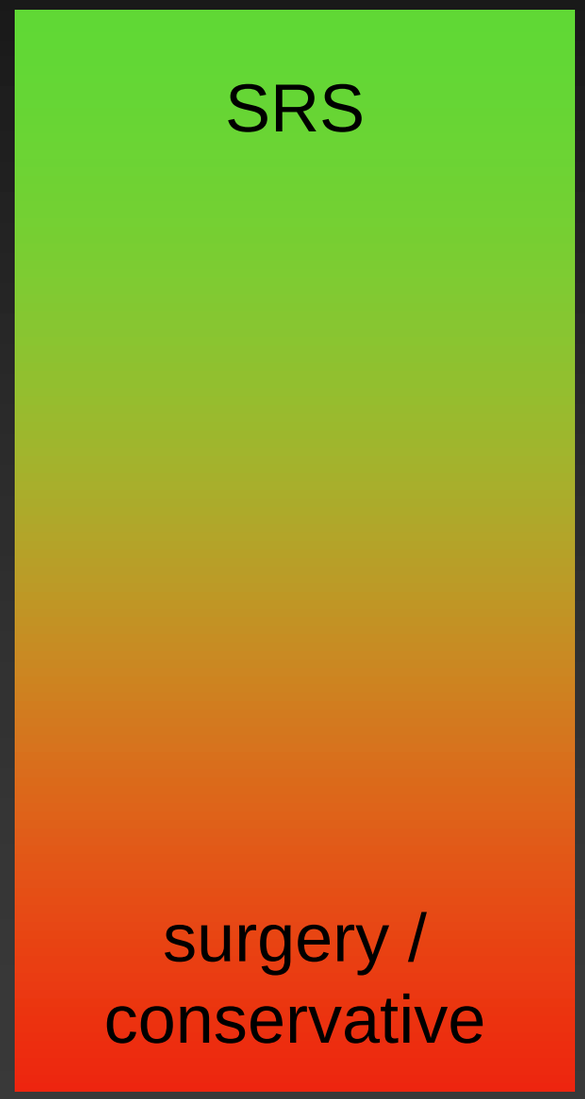
best candidates ?

small, deep-seated AVM

small, superficial AVM

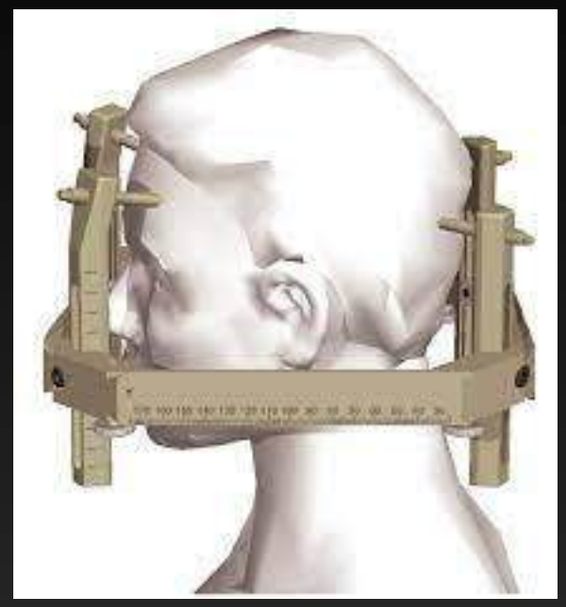
large, deep-seated AVM

large, superficial AVM



SRS technique

- Positioning of stereotactic frame



- acquisition of images
- Digital Subtraction Angiography
- MR and MRA (TOF),
- CBCT-A

- Dosimetry planning
- Radiation delivery

Utility (necessity) for DSA

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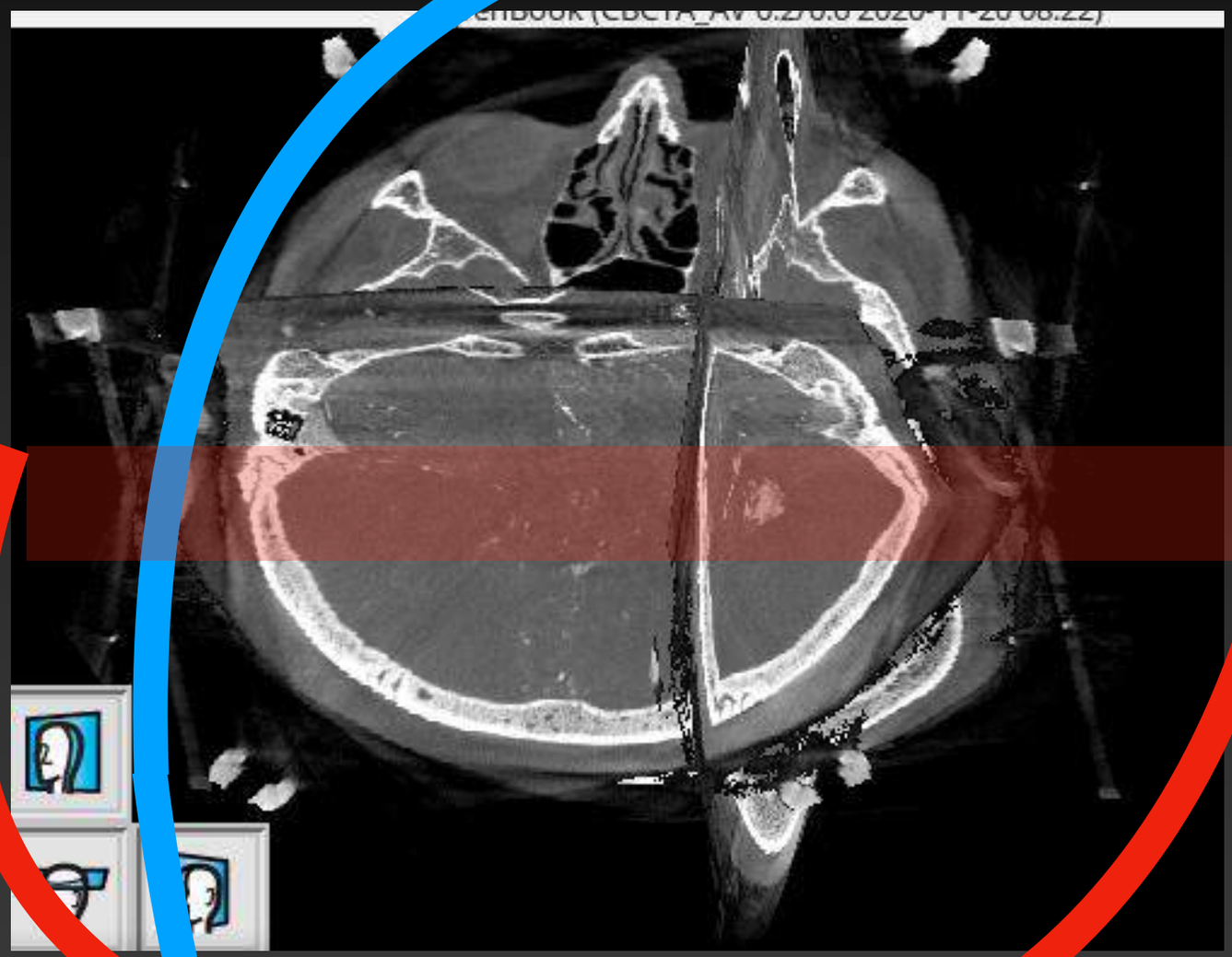
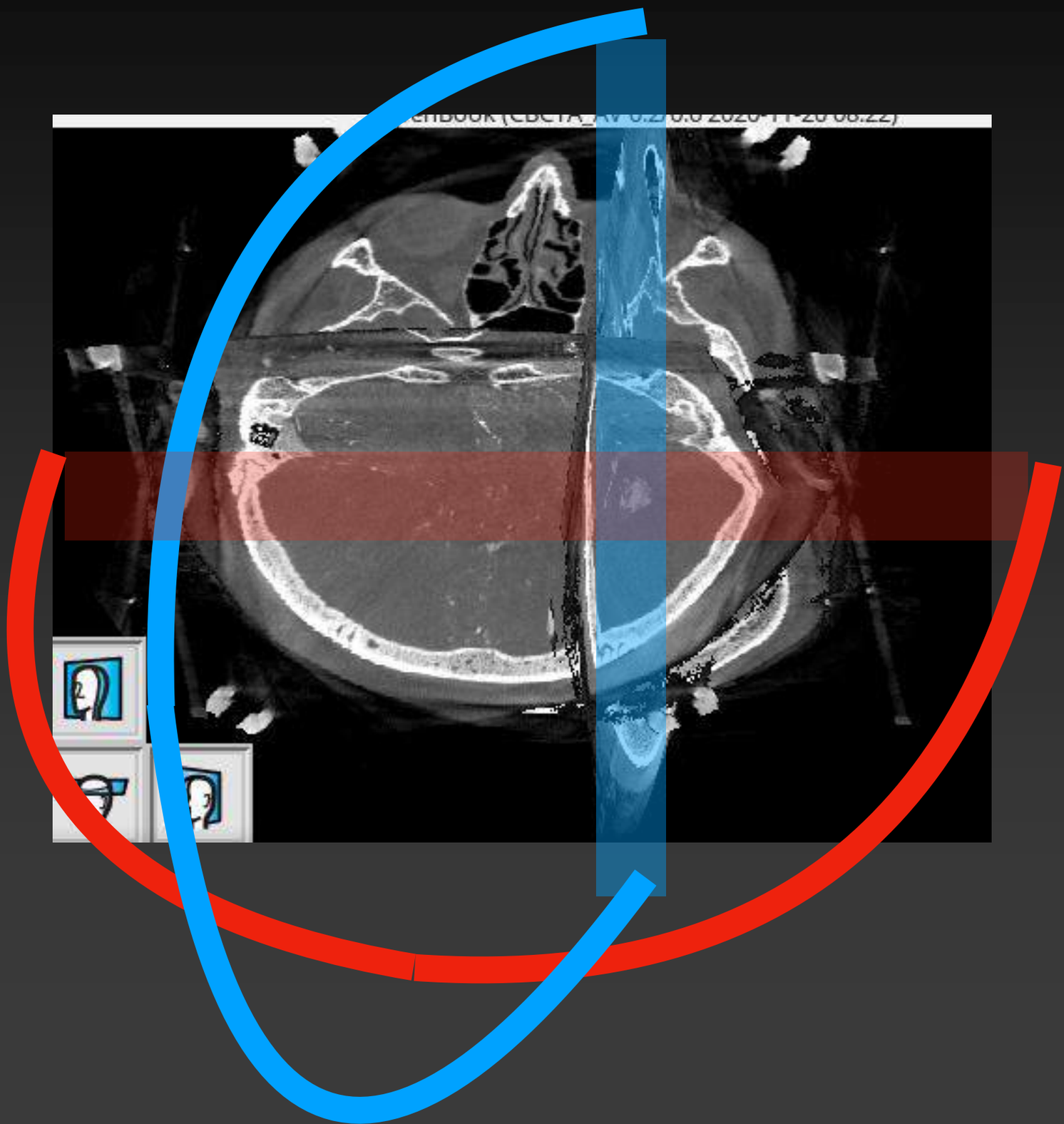


Utility (necessity) for DSA



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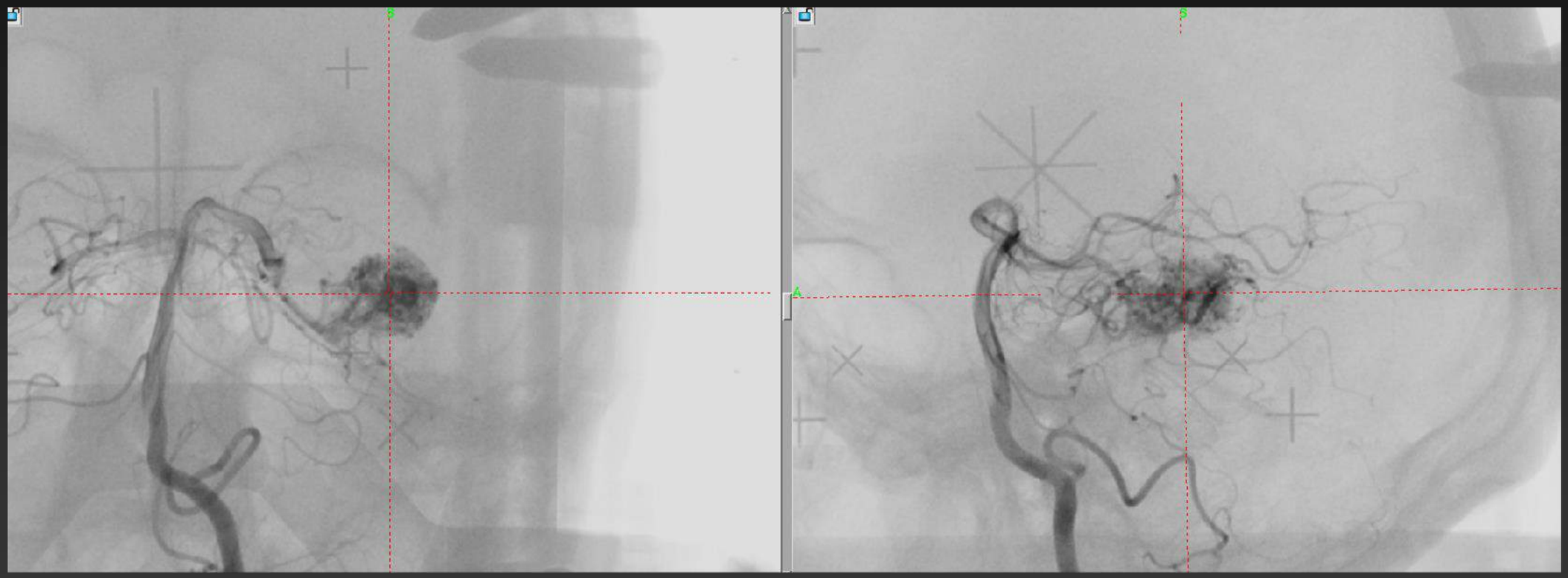

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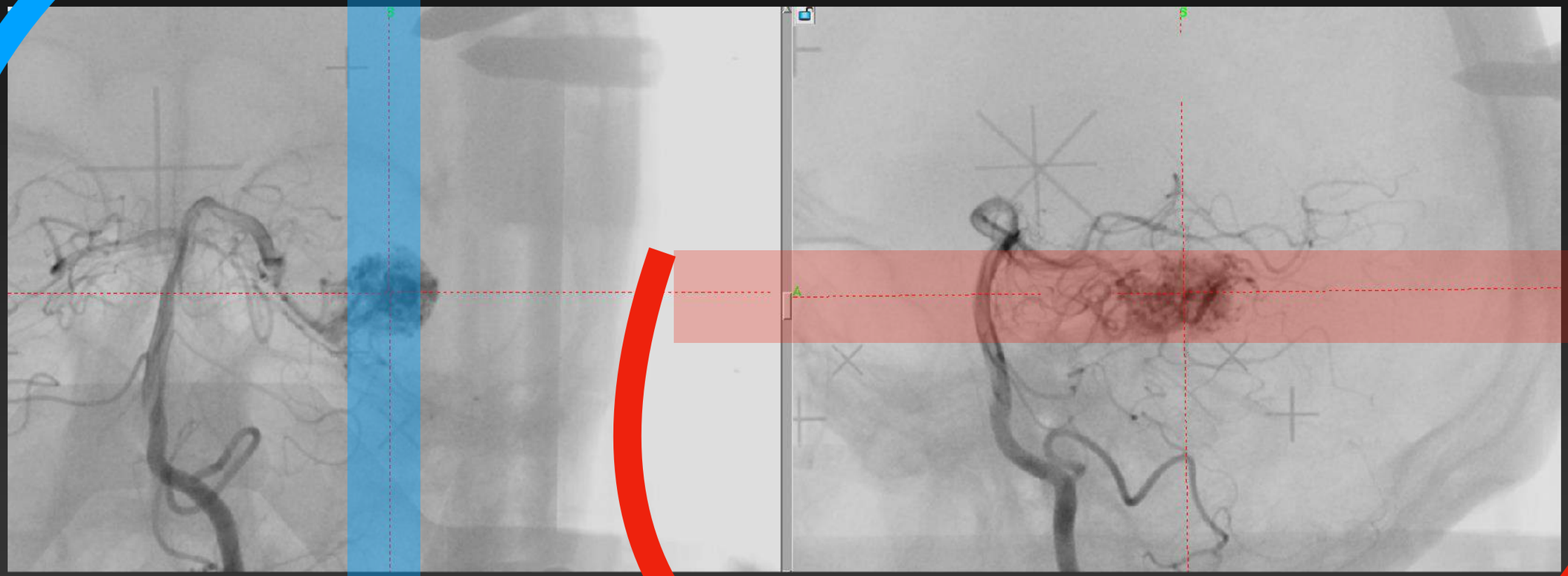
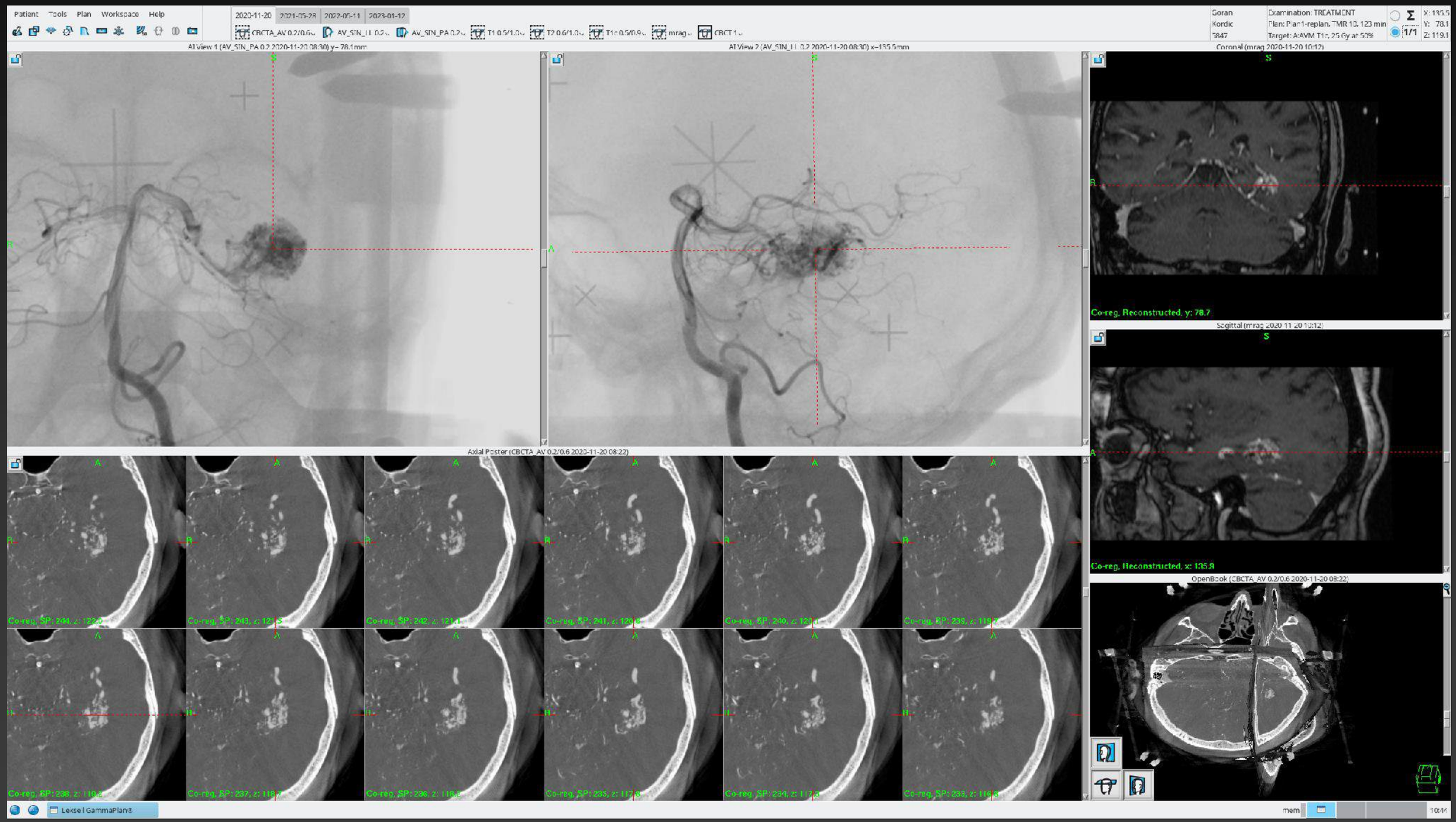
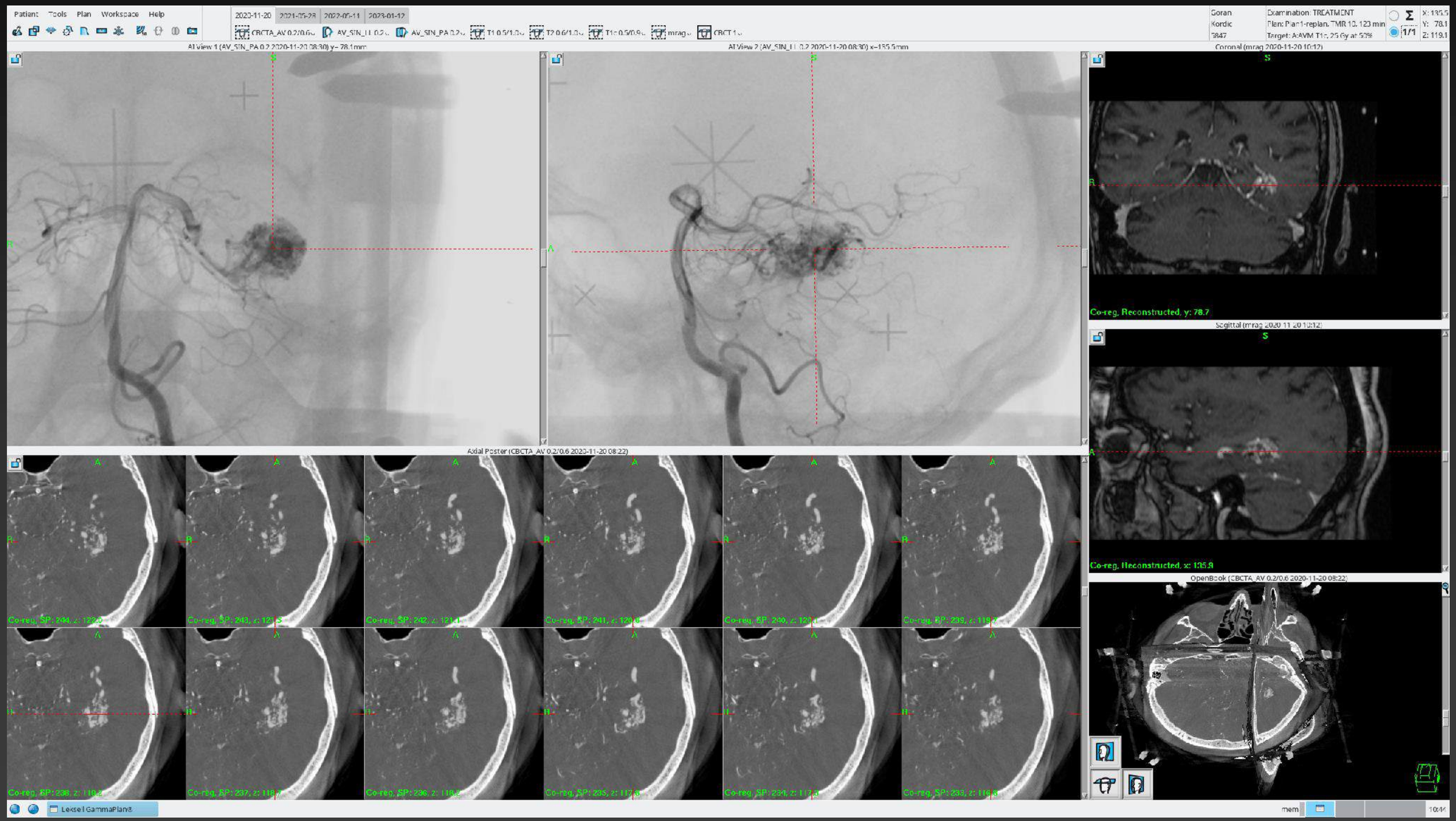


Utility (necessity) for DSA



Utility (necessity) for CBCT-A



Radiosurgery planning (dosimetry)

- factors we consider:
- volume
- location (eloquency, critical structures)
- prior hemorrhage, encephalomalacia
- prior embolisation
- radio surgical parameters (GI, conformity..)

Outcomes

- Obliteration rate
- Control of seizures (?)

Outcomes

- Obliteration rate
- …. time to obliteration 1-3 yrs (continues to rise up to 10 yrs)

Outcomes

- Obliteration rate
- …. time to obliteration 1-3 yrs (continues to rise up to 10 yrs)
- why ??

Outcomes

- Obliteration rate
- …. time to obliteration 1-3 yrs (continues to rise up to 10 yrs)
- why ??

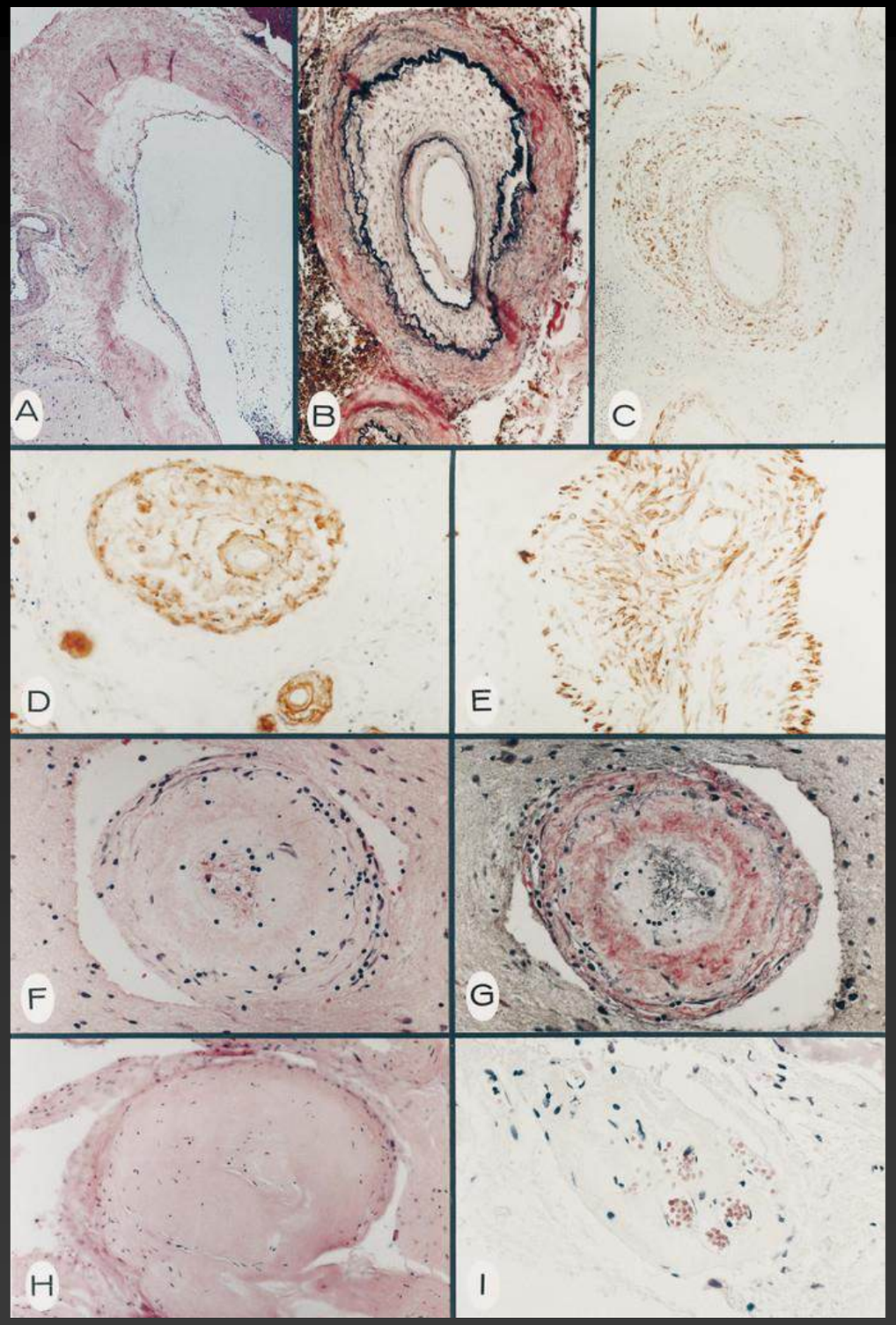
- answer in radiobiology !!!

Radiobiology

- in radiobiology, two distinct tissue typer : early-responding (tumor, skin, mucosa, GI tract…) and late-responding tissues
- endothelial cells correspond to late-responding tissues
- more susceptible to single, high dose of radiation

Radiobiology

- effect of radiation is damage to endothelial cells of nidus
- followed by initiation of a chronic inflammatory process
- formation of granulation tissue, fibroblasts, new capillaries
- results in a radiation-induced vasculopathy, with progressive narrowing of vessels till thrombosis and occlusion
- takes time…



Histopathology of arteriovenous malformations after gamma knife radiosurgery

Bernard F. Schneider M.D., Ph.D., David A. Eberhard M.D., Ph.D., and Ladislau E. Steiner M.D., Ph.D.

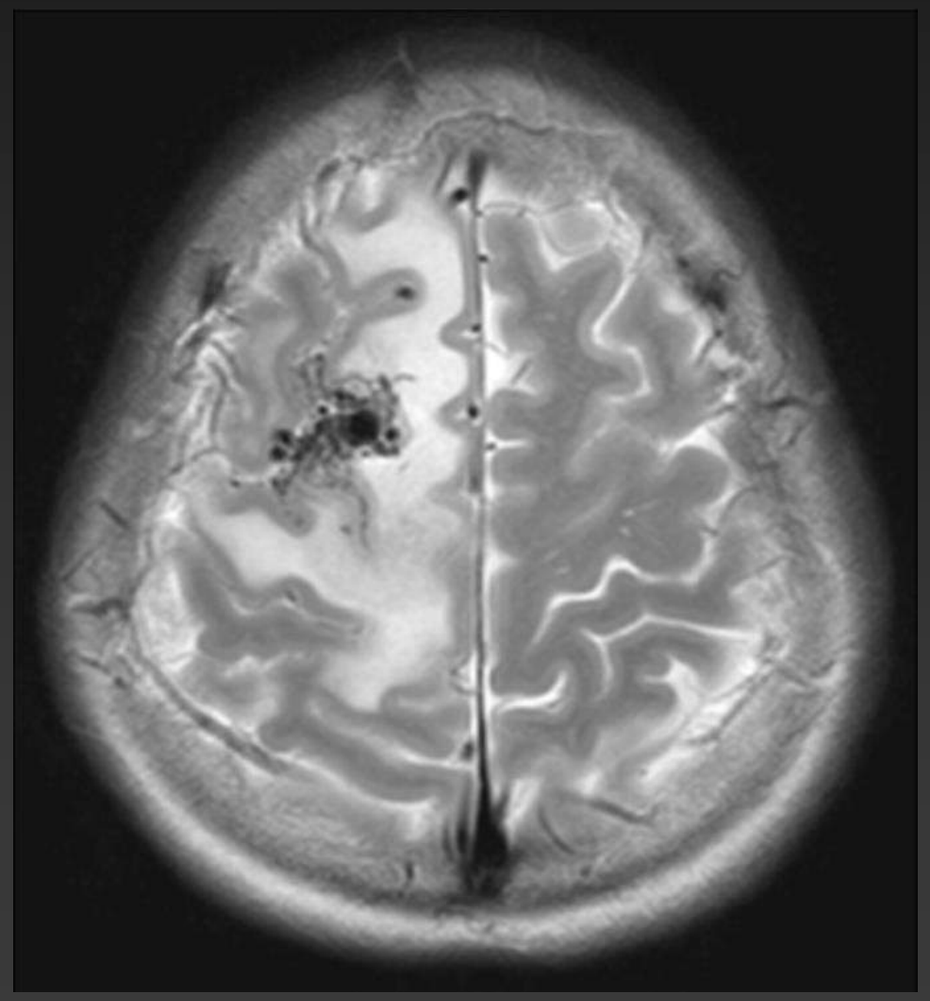
Page Range: 352–357
Volume/Issue: Volume 87: Issue 3
DOI link: https://doi.org/10.3171/jns.1997.87.3.0352

Outcomes

- Obliteration rate
- dependant on volume, marginal dose
  - < 1 cc obliteration 88%
  - 1-3 cc obliteration 78%
  - > 3 cc obliteration 60%
- seizure control over 70%

Complications

- 3-5 % neurological complications
- 6-9 % temporary ARE
- 1-3 % permanent ARE



- risk for complications higher in larger volume, previous embolisation, eloquent regions
- th: steroids, hyperbaric O2, bevacizumab…

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Lancet. 2014 February 15; 383(9917): 614–621. doi:10.1016/S0140-6736(13)62302-8.

Medical management with or without interventional therapy for unruptured brain arteriovenous malformations (ARUBA): a multicentre, non-blinded, randomised trial

Prof J P Mohr, MD[*], Prof Michael K Parides, PhD[*], Prof Christian Stapf, MD[*], Ellen Moquete, RN, Claudia S Moy, PhD, Jessica R Overbey, MS, Prof Rustam Al-Shahi Salman, FRCP, Prof Eric Vicaut, MD, Prof William L Young, MD[†], Prof Emmanuel Houdart, MD, Prof Charlotte Cordonnier, MD, Prof Marco A Stefani, MD, Andreas Hartmann, MD, Prof Rüdiger von Kummer, MD, Prof Alessandra Biondi, MD, Prof Joachim Berkefeld, MD, Catharina J M Klijn, MD, Kirsty Harkness, MD, Richard Libman, MD, Xavier Barreau, MD, and **Prof Alan J Moskowitz, MD for the international ARUBA investigators[‡]**

ARUBA

- intent to recruit 400 patients with ubAVMs
- follow for 5-10 yrs

- Prematurely halted after 33 months

- reported superior outcome for medical management over surgery (embo, microsurgery, radio surgery combined)

ARUBA

- substantial criticism !!
- bias in therapy
- short follow-up !!!

Treatment and outcomes of ARUBA-eligible patients with unruptured brain arteriovenous malformations at a single institution

W. Caleb Rutledge, M.D.,[1] Adib A. Abla, M.D.,[1] Jeffrey Nelson, M.S.,[2] Van V. Halbach, M.D.,[3] Helen Kim, Ph.D.,[2] and Michael T. Lawton, M.D.[1,2]

[1]Department of Neurological Surgery, University of California, San Francisco; [2]Center for Cerebrovascular Research, Department of Anesthesia and Perioperative Care, University of California, San Francisco; and [3]Division of Neurointerventional Radiology, University of California, San Francisco, California

Object. Management of unruptured arteriovenous malformations (AVMs) is controversial. In the first randomized trial of unruptured AVMs (A Randomized Trial of Unruptured Brain Arteriovenous Malformations [ARUBA]), medically managed patients had a significantly lower risk of death or stroke and had better outcomes. The University of California, San Francisco (UCSF) was one of the participating ARUBA sites. While 473 patients were screened for eligibility, only 4 patients were enrolled in ARUBA. The purpose of this study is to report the treatment and outcomes of all ARUBA-eligible patients at UCSF.

Methods. The authors compared the treatment and outcomes of ARUBA-eligible patients using prospectively collected data from the UCSF brain AVM registry. Similar to ARUBA, they compared the rate of stroke or death in observed and treated patients and used the modified Rankin Scale to grade outcomes.

Results. Of 74 patients, 61 received an intervention and 13 were observed. Most treated patients had resection with or without preoperative embolization (43 [70.5%] of 61 patients). One of the 13 observed patients died after AVM hemorrhage. Nine of the 61 treated patients had a stroke or died. There was no significant difference in the rate of stroke or death (HR 1.34, 95% CI 0.12–14.53, $p = 0.81$) or clinical impairment (Fisher's exact test, $p > 0.99$) between observed and treated patients.

Conclusions. The risk of stroke or death and degree of clinical impairment among treated patients was lower than reported in ARUBA. The authors found no significant difference in outcomes between observed and treated ARUBA-eligible patients at UCSF. Results in ARUBA-eligible patients managed outside that trial led to an entirely different conclusion about AVM intervention, due to the primary role of surgery, judicious surgical selection with established outcome predictors, and technical expertise developed at high-volume AVM centers.
(http://thejns.org/doi/abs/10.3171/2014.7.FOCUS14242)

Key Words • arteriovenous malformation • ARUBA • observation • microsurgical resection

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Key Words • **arteriovenous**
microsurgical resection

Gamma Knife Radiosurgery for ARUBA-Eligible Patients with Unruptured Brain Arteriovenous Malformations

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ABSTRACT

Background: A randomized trial of unruptured brain arteriovenous malformations (ARUBA) reported superior outcomes in conservative management compared to interventional treatment. There were numerous limitations to the study. This study aimed to investigate the efficacy of gamma knife radiosurgery (GKS) for patients with brain arteriovenous malformations (AVMs) by comparing its outcomes to those of the ARUBA study.

Methods: We retrospectively reviewed ARUBA-eligible patients treated with GKS from June 2002 to September 2017 and compared against those in the ARUBA study. AVM obliteration and hemorrhage rates, and clinical outcomes following GKS were also evaluated.

Results: The ARUBA-eligible cohort comprised 264 patients. The Spetzler-Martin grade was Grade I to II in 52.7% and III to IV in 47.3% of the patients. The mean AVM nidus volume, marginal dose, and follow-up period were 4.8 cm^3, 20.8 Gy, and 55.5 months, respectively. AVM obliteration was achieved in 62.1%. The annual hemorrhage rate after GKS was 3.4%. A stroke or death occurred in 14.0%. The overall stroke or death rate of the ARUBA-eligible cohort was significantly lower than that of the interventional arm of the ARUBA study ($P < 0.001$) and did not significantly differ from that of the medical arm in the ARUBA study ($P = 0.601$).

Conclusion: GKS was shown to achieve a favorable outcome with low procedure-related morbidity in majority of the ARUBA-eligible patients. The outcome after GKS in our patients was not inferior to that of medical care alone in the ARUBA study. It is suggested that GKS is rather superior to medical care considering the short follow-up duration of the ARUBA study.

Stereotactic Radiosurgery for Arteriovenous Malformations: The Effect of Treatment Period on Patient Outcomes

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Robert L. Foote, MD‡

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BACKGROUND: Stereotactic radiosurgery (SRS) has been performed on patients with cerebral arteriovenous malformations (AVMs) for over 40 years.
OBJECTIVE: To evaluate the impact of treatment period on obliteration, intracranial hemorrhage (ICH), and radiation-induced complications (RICs).
METHODS: Retrospective comparison of 381 AVM patients having SRS during a 20-year period (group 1, January 1990 through March 1997, n = 160; group 2, April 1997 through December 2009, n = 221). The median radiological and clinical follow-up after initial SRS was 77 months and 93 months, respectively.
RESULTS: Obliteration was 59.1% at 4 years and 85.1% at 8 years. Obliteration was more common in patients with hemispheric or cerebellar AVMs ($P = .001$), smaller prescription isodose volume (PIV) ($P < .001$), and group 1 patients ($P < .001$). The ICH rate was 7.7% at 4 years and 10.6% at 8 years. ICH was more common in older patients ($P = .02$), patients with deep AVM ($P = .01$), and larger PIV ($P < .001$). There was no difference in the ICH rate between the treatment groups ($P = .18$). The rate of permanent RICs was 4.4% at 4 years and 8.6% at 8 years. RICs were more common with larger PIVs ($P < .001$) and group 1 patients ($P = .02$). There was no difference in the number of patients having obliteration without new deficits between the 2 treatment periods (68.8% vs 73.3%, $P = .33$).
CONCLUSION: Advances in SRS procedures over the past 20 years have resulted in a lower risk of RIC, but fewer patients had AVM obliteration. Increasing the prescription dose for patients with medium- and large-volume AVMs by using current conformal dose-planning techniques may improve the obliteration rate while maintaining a low risk of RICs.

KEY WORDS: Arteriovenous malformation, Complications, Hemorrhage, Obliteration rate, Stereotactic radiosurgery

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Annual hemorrhage rate after SRS 1.3%

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ORIGINAL RESEARCH

Evaluation of the radiosurgical treatment of cerebral arteriovenous malformations: a retrospective single-center analysis of three decades

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J NeuroIntervent Surg 2020;12

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J NeuroIntervent Surg 2020;12

Overall annual hemorrhage rate after first GKRS: 1.3%

The Risk of Stroke or Clinical Impairment After Stereotactic Radiosurgery for ARUBA-Eligible Patients

Bruce E. Pollock, MD; Michael J. Link, MD; Robert D. Brown, MD

Background and Purpose—The best management of patients with unruptured brain arteriovenous malformations (BAVM) is controversial. In this study, we analyzed the stroke rate and functional outcomes of patients having stereotactic radiosurgery (SRS) for unruptured BAVM using the same eligibility criteria and primary end points as the ARUBA trial.

Methods—Retrospective observational study of 174 ARUBA-eligible patients having SRS from 1990 to 2005.

Results—The median follow-up after SRS was 64 months. Fifteen patients (8.7%) had a hemorrhagic stroke at a median of 21 months after SRS. Six patients (3.5%) had a focal neurological deficit and 4 patients died (2.3%). The risk of stroke or death was 10.3% at 5 years and 11.5% at 10 years. Twelve additional patients (6.9%) had a focal neurological deficit from either radiation-related complications (n=7) or subsequent resection (n=5). The risk of patients' having clinical impairment (modified Rankin Score ≥2) was 8.4% at 5 years and 12.0% at 10 years. Increasing BAVM volume was associated with both stroke or death (hazard ratio=1.06; 95% confidence interval, 1.0–1.11; P=0.04) and clinical impairment (hazard ratio=1.06; 95% confidence interval, 1.01–1.09; P=0.01). The 10-year risk of stroke or death and clinical impairment for patients with BAVM ≤5.6 cm^3 was 5% and 4%, respectively.

Conclusions—The observed risk of stroke or death after SRS was approximately 2% per year for the first 5 years after SRS, declining to 0.2% annually for years 6 to 10. Patients with small volume BAVM may benefit from SRS compared with the natural history of unruptured BAVM over the planned follow-up interval of the ARUBA trial (5–10 years). **(*Stroke*. 2013;44:437-441.)**

Key Words: arteriovenous malformation ■ hemorrhage ■ stereotactic radiosurgery ■ stroke

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Background and Purpose—The best management of patients with unruptured brain arteriovenous malformations (BAVM) is controversial. In this study, we analyzed the stroke rate and functional outcomes of patients having stereotactic radiosurgery (SRS) for unruptured BAVM using the same eligibility criteria and primary end points as the ARUBA trial.

Methods—Retrospective observational study of 174 ARUBA-eligible patients having SRS from 1990 to 2005.

Results—The median follow-up after SRS was 64 months. Fifteen patients (8.7%) had a hemorrhagic stroke at a median of 21 months after SRS. Six patients (3.5%) had a focal neurological deficit and 4 patients died (2.3%). The risk of stroke or death was 10.3% at 5 years and 11.5% at 10 years. Twelve additional patients (6.9%) had a focal neurological deficit from either radiation-related complications (n=7) or subsequent resection (n=5). The risk of patients' having clinical impairment (modified Rankin Score ≥2) was 8.4% at 5 years and 12.0% at 10 years. Increasing BAVM volume was associated with both stroke or death (hazard ratio=1.06; 95% confidence interval, 1.0–1.11; P=0.04) and clinical impairment (hazard ratio=1.06; 95% confidence interval, 1.01–1.09; P=0.01). The 10-year risk of stroke or death and clinical impairment for patients with BAVM ≤5.6 cm^3 was 5% and 4%, respectively.

Conclusions—The observed risk of stroke or death after SRS was approximately 2% per year for the first 5 years after SRS, declining to 0.2% annually for years 6 to 10. Patients with small volume BAVM may benefit from SRS compared with the natural history of unruptured BAVM over the planned follow-up interval of the ARUBA trial (5–10 years). (***Stroke*.** **2013;44:437-441.**)

Key Words: arteriovenous malformation ■ hemorrhage ■ stereotactic radiosurgery ■ stroke

REVIEW: CEREBROVASCULAR

Stereotactic Radiosurgery for A Randomized Trial of Unruptured Brain Arteriovenous Malformations-Eligible Patients: A Meta-Analysis

Ilyas, Adeel MD*; Chen, Ching-Jen MD‡; Abecassis, Isaac Josh MD§; Al-Saiegh, Fadi MD‡; Ironside, Natasha MBChB‖; Jabbour, Pascal M. MD‡; Tjoumakaris, Stavropoula MD‡; Gooch, M. Reid MD‡; Lee, Cheng-Chia MD, PhD¶; Sheehan, Jason P. MD, PhD‖; Ding, Dale MD§

Author Information

Neurosurgery 91(5):p 684-692, November 2022. | **DOI:** 10.1227/neu.0000000000002115

- study cohort included 8 studies comprising 1620 ARUBA-eligible patients who underwent SRS
- mean follow-up duration was 80 months
- rates of radiologic, symptomatic, and permanent radiation-induced changes were 45%, 11%, and 2%, respectively
- obliteration rate was 68% at last follow-up
- post-SRS hemorrhage and mortality rates were 8%, and 2%, respectively

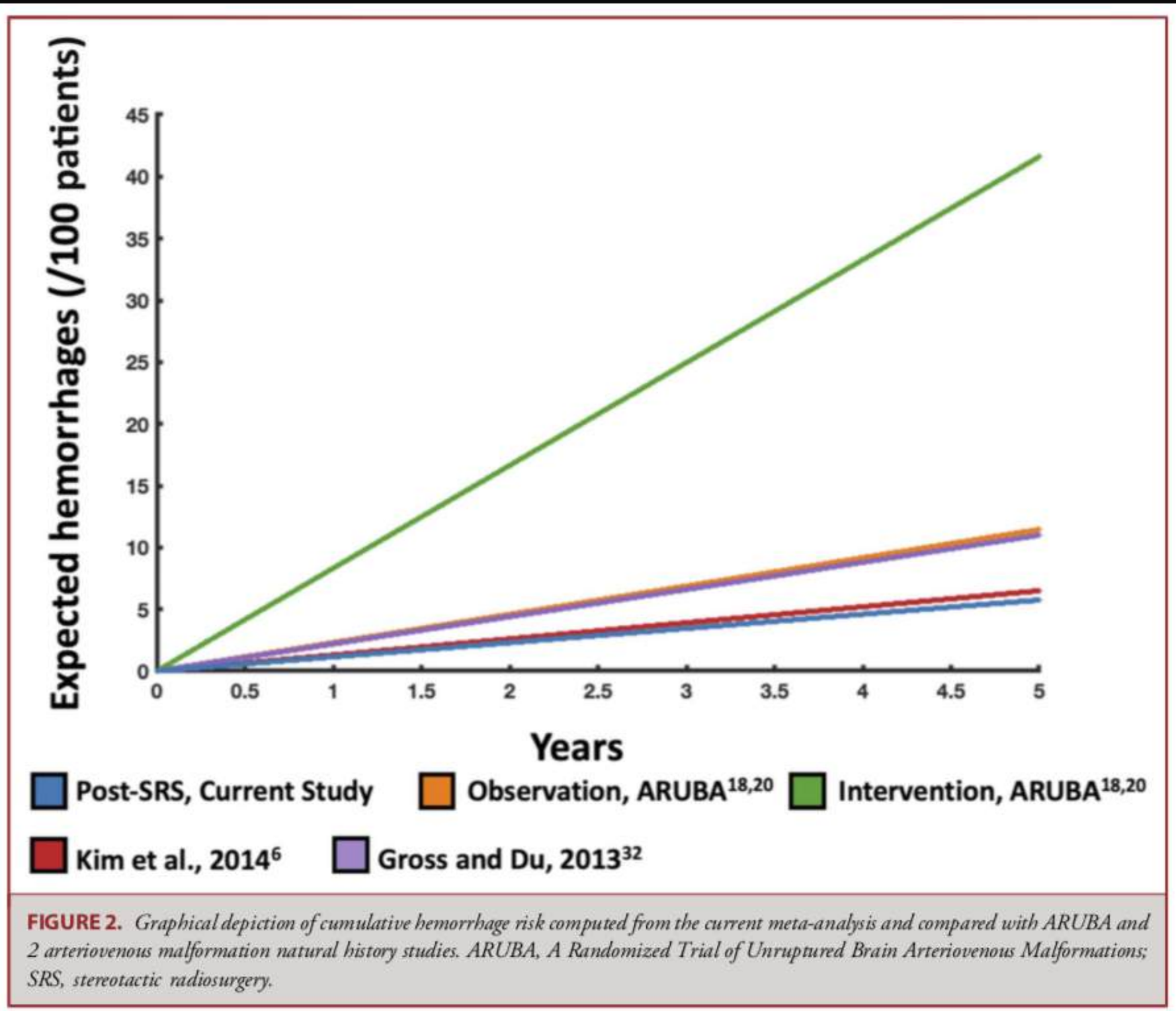


FIGURE 2. *Graphical depiction of cumulative hemorrhage risk computed from the current meta-analysis and compared with ARUBA and 2 arteriovenous malformation natural history studies. ARUBA, A Randomized Trial of Unruptured Brain Arteriovenous Malformations; SRS, stereotactic radiosurgery.*

REVIEW: CEREBROVASCULAR

Stereotactic Radiosurgery for A Randomized Trial of Unruptured Brain Arteriovenous Malformations-Eligible Patients: A Meta-Analysis

Ilyas, Adeel MD*; Chen, Ching-Jen MD‡; Abecassis, Isaac Josh MD§; Al-Saiegh, Fadi MD‡; Ironside, Natasha MBChB‖; Jabbour, Pascal M. MD‡; Tjoumakaris, Stavropoula MD‡; Gooch, M. Reid MD‡; Lee, Cheng-Chia MD, PhD¶; Sheehan, Jason P. MD, PhD‖; Ding, Dale MD§

Author Information

Neurosurgery 91(5):p 684-692, November 2022. | **DOI:** 10.1227/neu.0000000000002115

- lower Spetzler-Martin grade (odds ratios [OR] = 0.84 [0.74-0.95], P = .005),
- lower radiosurgery-based AVM score (OR = 0.75 [0.64-0.95], P = .011),
- lower Virginia Radiosurgery AVM Scale (OR = 0.86 [0.78-0.95], P = .003), and
- higher margin dose (OR = 1.13 [1.02-1.25], P = .025)
- were associated with obliteration

REVIEW: CEREBROVASCULAR

Stereotactic Radiosurgery for A Randomized Trial of Unruptured Brain Arteriovenous Malformations-Eligible Patients: A Meta-Analysis

Ilyas, Adeel MD[*]; Chen, Ching-Jen MD[‡]; Abecassis, Isaac Josh MD[§]; Al-Saiegh, Fadi MD[‡]; Ironside, Natasha MBChB[‖]; Jabbour, Pascal M. MD[‡]; Tjoumakaris, Stavropoula MD[‡]; Gooch, M. Reid MD[‡]; Lee, Cheng-Chia MD, PhD[¶]; Sheehan, Jason P. MD, PhD[‖]; Ding, Dale MD[§]

Author Information

Neurosurgery 91(5):p 684-692, November 2022. | **DOI:** 10.1227/neu.0000000000002115

CONCLUSION:

SRS carries a favorable risk to benefit profile for appropriately selected ARUBA-eligible patients, particularly those with smaller volume AVMs. Our findings suggest that the results of ARUBA do not reflect the real-world safety and efficacy of SRS for unruptured AVMs.

Funded by
the European Union

Case 1

- 44 y.o. male
- Medical history - mild retardation, epilepsy for many years
- development of instability in gait
- CT-A, MR-A - signs of bAVM
- admitted to Neurology for DSA evaluation

Patient Tools Plan Workspace Help

2020-11-20 | 2021-05-28 | 2022-05-11 | 2023-01-12

CBCTA_AV 0.2/0.6... | AV_SIN_LL 0.2... | AV_SIN_PA 0.2... | T1 0.5/1.0... | T2 0.6/1.0... | T1c 0.5/0.9... | mrag... | CBCT 1...

Goran
Kordic
7847

Examination: TREATMENT
Plan: Plan1-replan, TMR 10, 123 min
Target: AcAVM T1c, 25 Gy at 50%

Σ
1/1

X: 135.5
Y: 78.1
Z: 119.8

Axial (mrag 2020-11-20 10:12)

Co-reg, SP: 65, z: 119.2

Axial1 (T2 0.6/1.0 2020-11-20 09:52)

Co-reg, SP: 67, z: 120.0

Leksell GammaPlan®

mem

10:15

Patient Tools Plan Workspace Help

2020-11-20 | 2021-05-28 | 2022-05-11 | 2023-01-12

CBCTA_AV 0.2/0.6... | AV_SIN_LL 0.2... | AV_SIN_PA 0.2... | T1 0.5/1.0... | T2 0.6/1.0... | T1c 0.5/0.9... | mrag... | CBCT 1...

Goran
Kordic
7847

Examination: TREATMENT
Plan: Plan1-replan, TMR 10, 123 min
Target: AcAVM T1c, 25 Gy at 50%

1/1

X: 135.5
Y: 78.1
Z: 119.1

AI View 1 (AV_SIN_PA 0.2 2020-11-20 08:30) y= 78.1mm

AI View 2 (AV_SIN_LL 0.2 2020-11-20 08:30) x=135.5mm

Coronal (mrag 2020-11-20 10:12)

Co-reg, Reconstructed, y: 78.7

Sagittal (mrag 2020-11-20 10:12)

Co-reg, Reconstructed, x: 135.5

Axial Poster (CBCTA_AV 0.2/0.6 2020-11-20 08:22)

Co-reg, SP: 244, z: 122.0 | Co-reg, SP: 243, z: 121.5 | Co-reg, SP: 242, z: 121.1 | Co-reg, SP: 241, z: 120.6 | Co-reg, SP: 240, z: 120.1 | Co-reg, SP: 239, z: 119.7

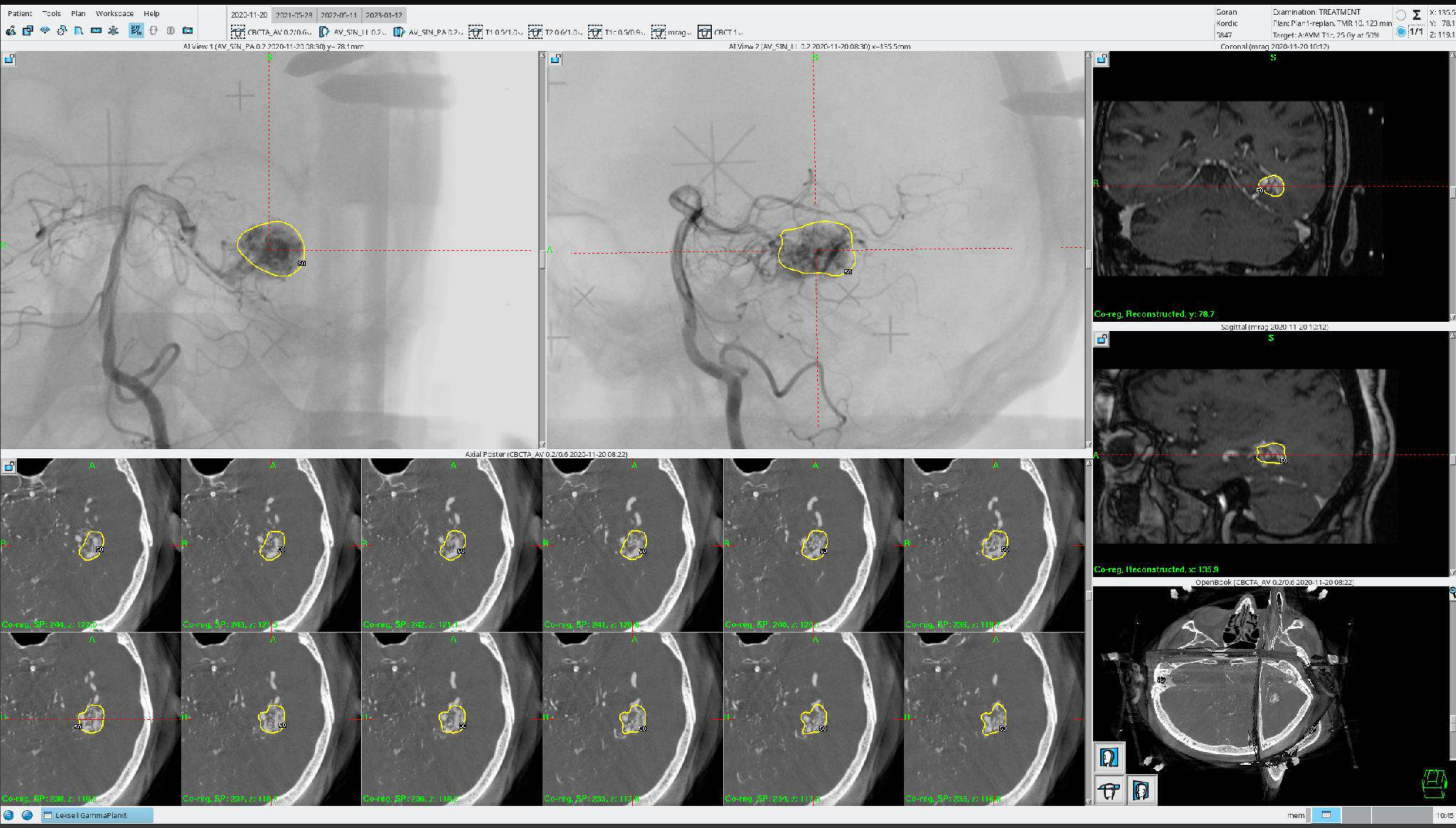
Co-reg, SP: 238, z: 119.2 | Co-reg, SP: 237, z: 118.7 | Co-reg, SP: 236, z: 118.2 | Co-reg, SP: 235, z: 117.8 | Co-reg, SP: 234, z: 117.3 | Co-reg, SP: 233, z: 116.8

OpenBook (CBCTA_AV 0.2/0.6 2020-11-20 08:22)

Leksell GammaPlan®

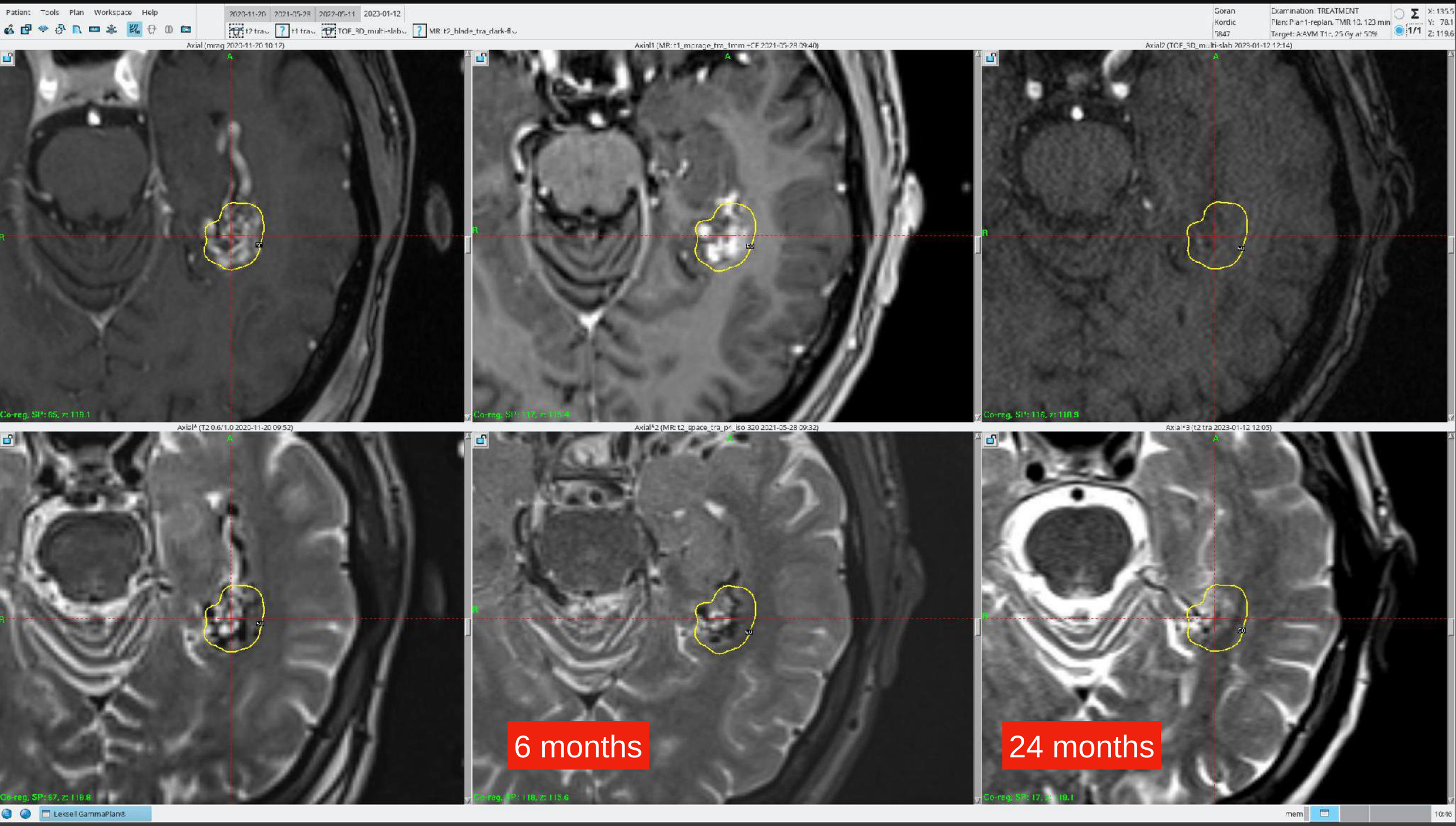
mem

10:44



Nidus volume : 1,571 ccm

PD 25 Gy / 50% isodose


6 months
24 months

Case 2

- 54 y.o. male
- Medical history - chronic gastritis, depression
- development of new-onset headaches
- CT-A, MR-A - unraptured bAVM occipital
- admitted to Neurology for DSA evaluation

Patient Tools Plan Workspace Help

2019-12-04 2020-05-20 2023-03-27

T1c T2 mregv T1c AV_SIN_LL 0.4 mm AV_SIN_PA 0.2 mm CBCTA_AV_SIN 0.4/0.9 CBCT 1

Manko
Dujmic
5414

Examination: TREATMENT
Plan: Plan5, TMR 10, 81 min
Target: AcAVM, 22.5 Gy at 50%

Σ
1/1

X: 103.2
Y: 99.8
Z: 95.9

Axial (T1c 2019-12-04 06:06)

A

R

Co-reg, SP: 116, z: 104.7

Axial1 (T2 2019-12-04 07:51)

A

R

Co-reg, SP: 112, z: 104.2

Lexsel GammaPlan®

mem

10:29

Patient Tools Plan Workspace Help

2019-12-04 2020-05-20 2023-03-27

T1c T2c mrag T1c AV_SIN_LL 0.4 mm c AV_SIN_PA 0.2 mm c CBCTA_AV_SIN 0.4/0.9 c CBCT 1 c

Mannko Dujmic 5414

Examination: TREATMENT
Plan: Plan5, TMR 10, 81 min
Target: AcAVM, 22.5 Gy at 50%

Σ 1/1

X: 112.5
Y: 50.4
Z: 75.0

AI View 1 (AV_SIN_PA 0.2 mm 2019-12-04 09:04) y= 50.4mm

AI View 2 (AV_SIN_LL 0.4 mm 2019-12-04 09:04) x=112.5mm

Coronal (mrag 2019-12-04 07:58)

Co-reg, Reconstructed, y: 48.0

Sagittal (mrag 2019-12-04 07:58)

Co-reg, Reconstructed, x: 112.8

Axial Poster (CBCTA_AV_SIN 0.4/0.9 2019-12-01 09:09)

SP: 175, z: 79.1 SP: 174, z: 78.6 SP: 173, z: 78.1 SP: 172, z: 77.7 SP: 171, z: 77.2 SP: 170, z: 76.7

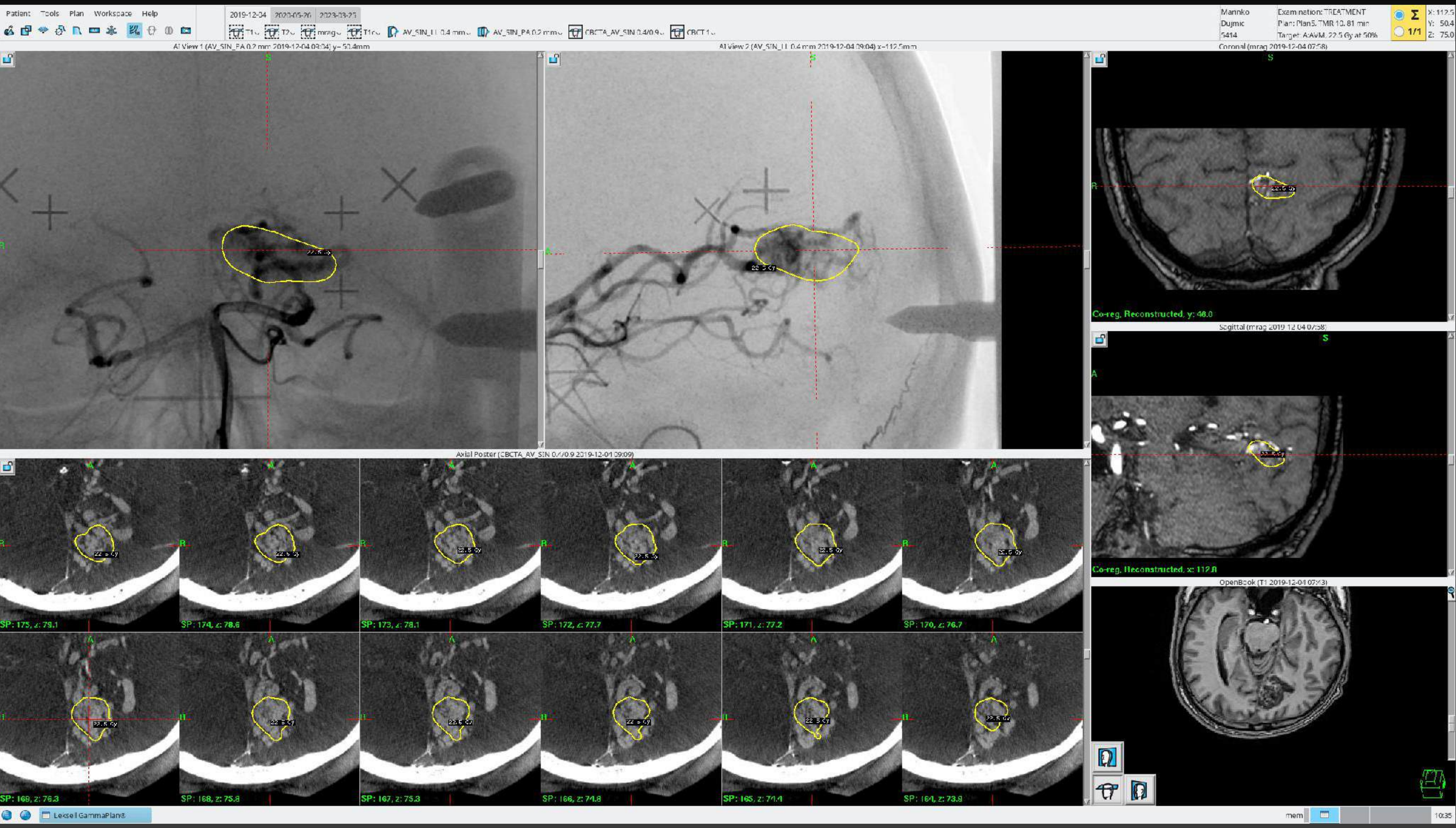
SP: 169, z: 76.3 SP: 168, z: 75.8 SP: 167, z: 75.3 SP: 166, z: 74.8 SP: 165, z: 74.4 SP: 164, z: 73.9

OpenBook (T1 2019-12-04 07:43)

Lekse I GammaPlan®

mem

10:35



Nidus volume : 1,616 ccm

PD 22.5 Gy / 50% isodose

Patient Tools Plan Workspace Help

2019-12-04 | 2020-05-20 | 2020-08-25

T1c | T2 | mrag | T1c | AV_SIN_LL 0.4 mm | AV_SIN_PA 0.2 mm | CBCTA_AV_SIN 0.4/0.9 | CBCT 1

Mannko
Dujmic
5414

Examination: TREATMENT
Plan: Plan5, TMR 10, 81 min
Target: AcAVM, 22.5 Gy at 50%

Σ
1/1

X: 112.5
Y: 50.4
Z: 75.0

AI View 1 (AV_SIN_PA 0.2 mm 2019-12-04 09:04) y= 50.4mm

AI View 2 (AV_SIN_LL 0.4 mm 2019-12-04 09:04) x=112.5mm

Coronal (mrag 2019-12-04 07:58)

Co-reg, Reconstructed, y: 48.0

Sagittal (mrag 2019-12-04 07:58)

Co-reg, Reconstructed, x: 112.5

Axial Poster (CBCTA_AV_SIN 0.4/0.9 2019-12-01 09:09)

SP: 175, z: 79.1 | SP: 174, z: 78.6 | SP: 173, z: 78.1 | SP: 172, z: 77.7 | SP: 171, z: 77.2 | SP: 170, z: 76.7

SP: 169, z: 76.3 | SP: 168, z: 75.8 | SP: 167, z: 75.3 | SP: 166, z: 74.8 | SP: 165, z: 74.4 | SP: 164, z: 73.9

OpenBook (T1 2019-12-04 07:43)

Lekse I GammaPlan®

mem

10:35

Patient Tools Plan Workspace Help

2019-12-04 2020-05-20 2023-03-27

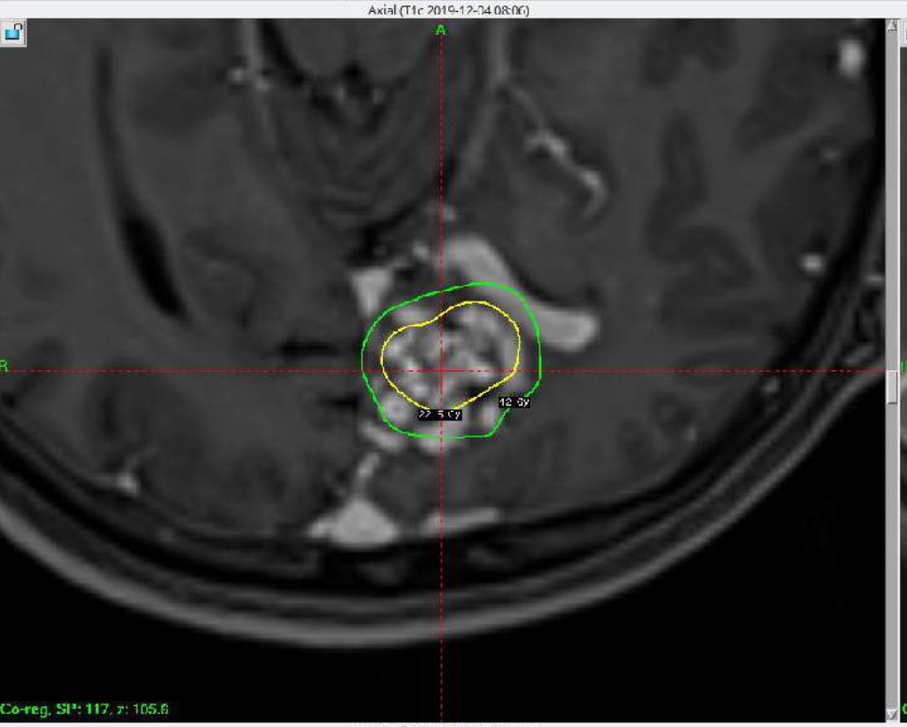
Mannko
Dujmic
5414

Examination: TREATMENT
Plan: Plan5, TMR 10, 81 min
Target: AcAVM, 22.5 Gy at 50%

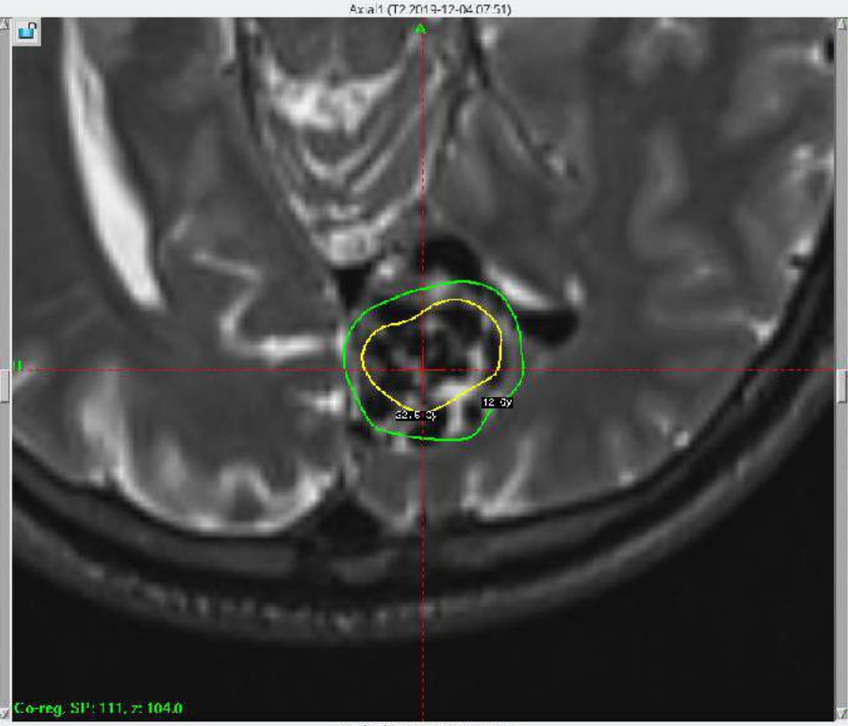
1/1

X: 112.5
Y: 50.4
Z: 75.0

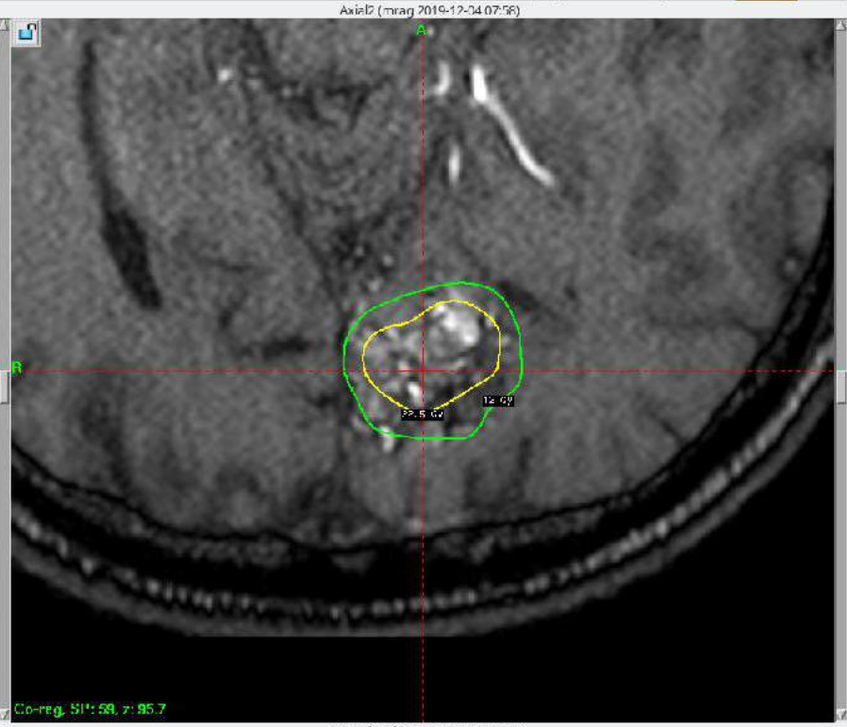
Axial (T1c 2019-12-04 08:06)



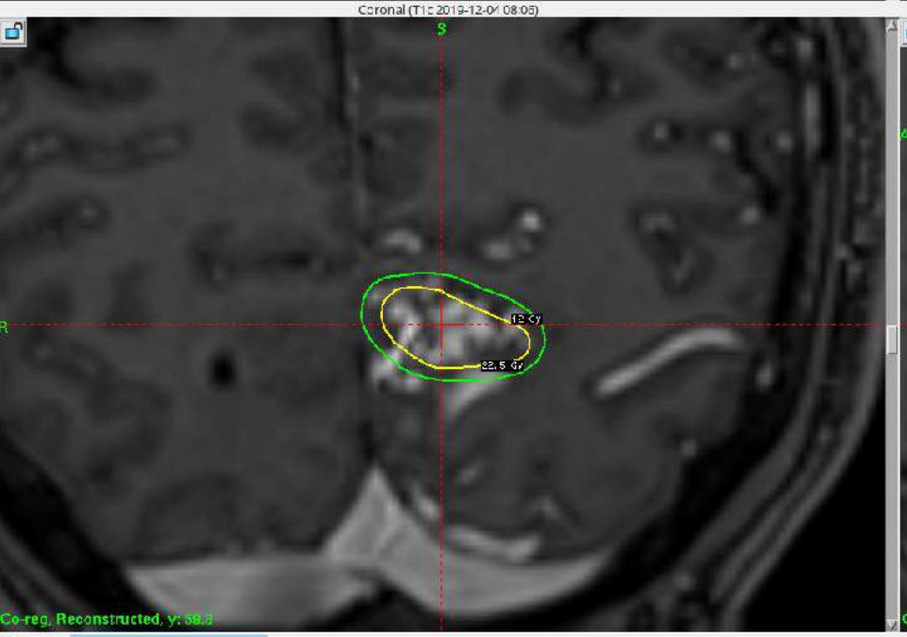
Axial1 (T2 2019-12-04 07:51)



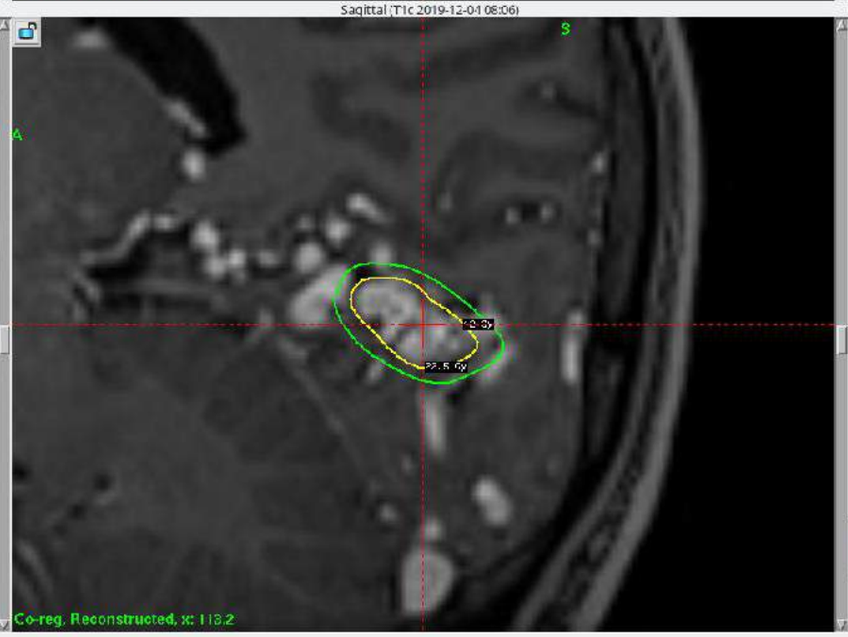
Axial2 (mrag 2019-12-04 07:56)



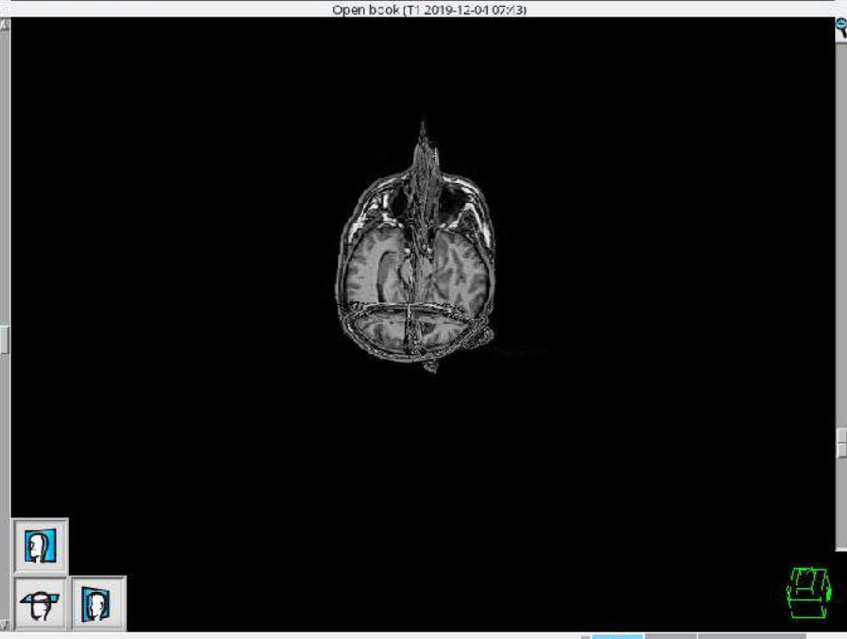
Coronal (T1c 2019-12-04 08:06)



Sagittal (T1c 2019-12-04 08:06)



Open book (T1 2019-12-04 07:43)



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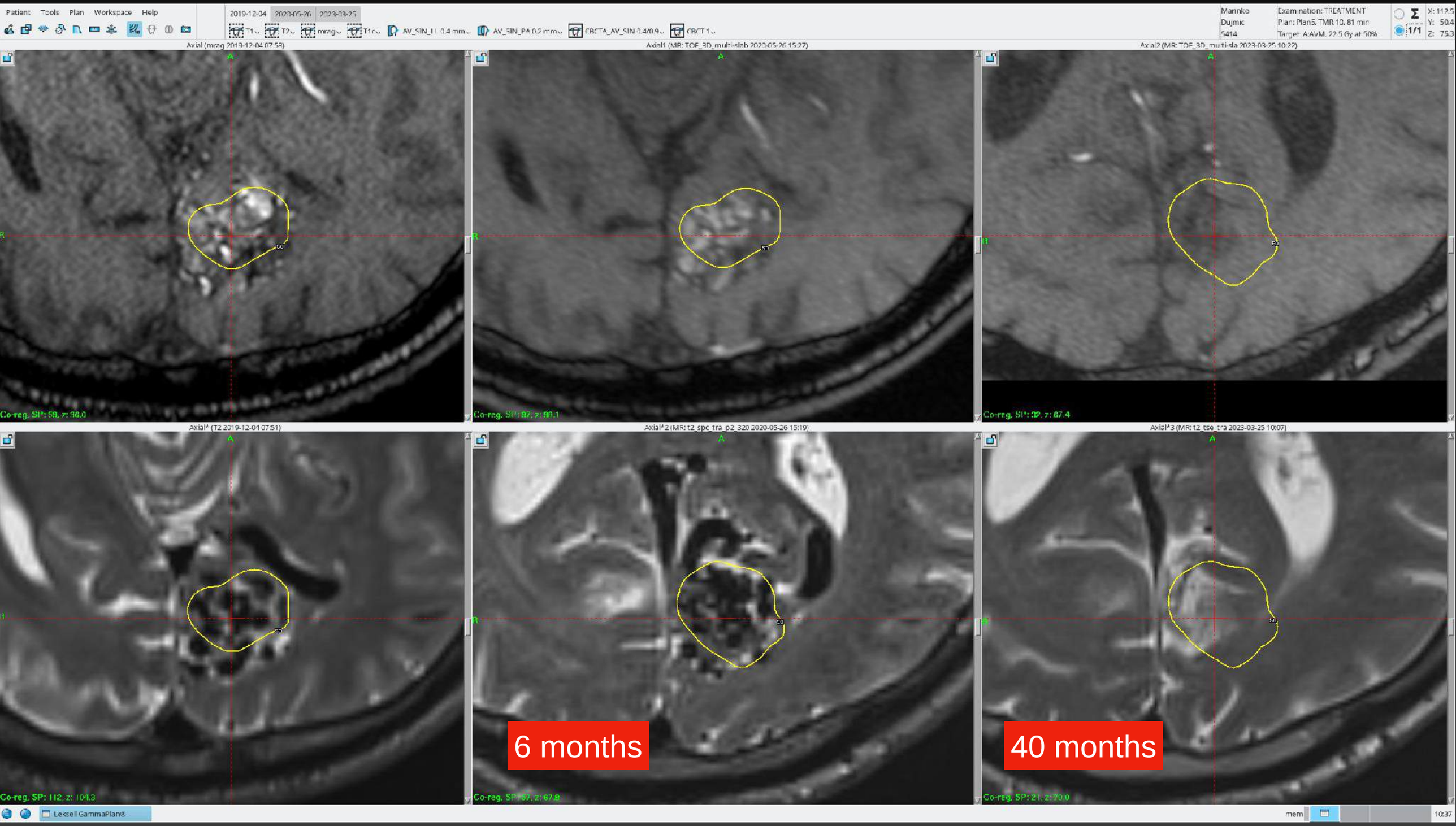
mem

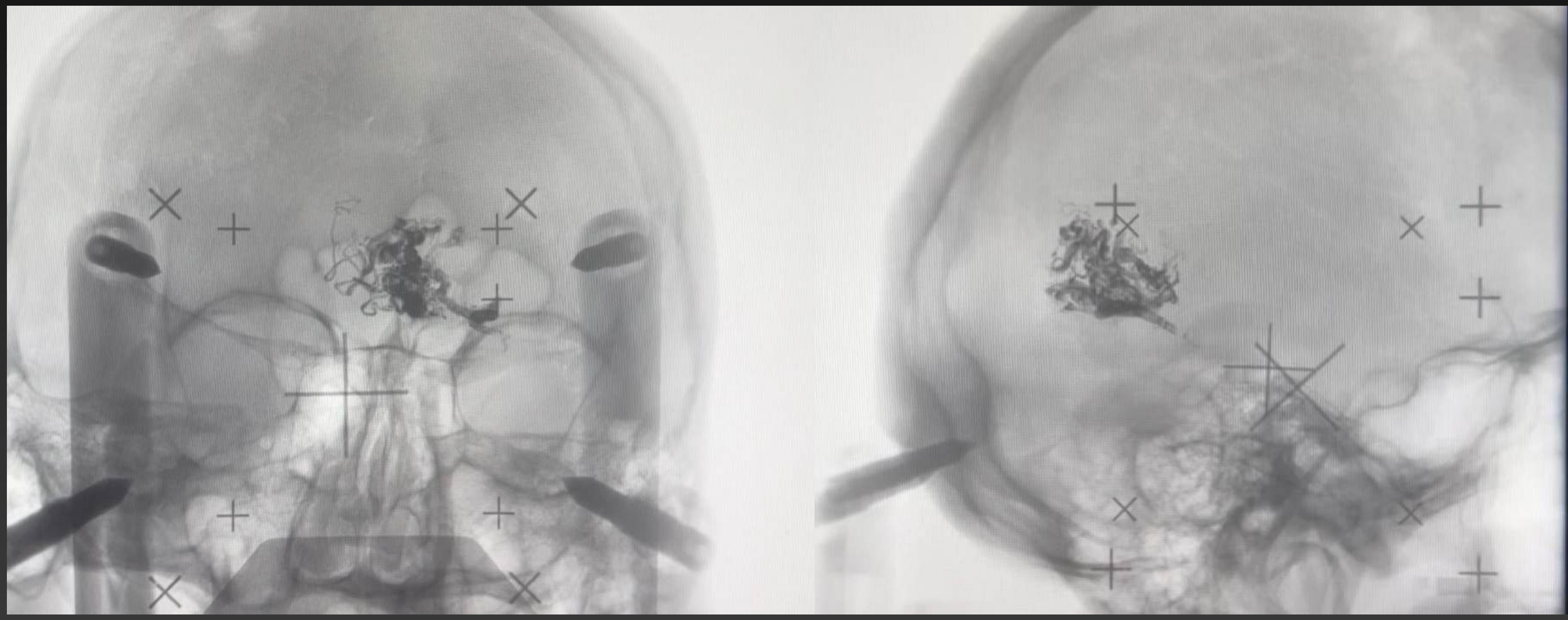
10:36


6 months
40 months

Funded by
the European Union

Case 3

- 50 y.o. male
- Medical history - IC hematoma, with hematocephalus 9 months previously
- CT-A, MR-A - bleeding from ruptured bAVM occipital
- status - right sided hemiparesis
- admitted to Neurology for DSA evaluation and embolisation
- partially embolised with Onyx
- referred to radiosurgery for residual nidus



Patient Tools Plan Workspace Help

2015-10-28 | 2019-01-03 | 2020-04-23

ACT SIN LL | ACT SIN PA | AV SIN LL | AV SIN PA | CBCT-A - ACT sin | CBCT-A - AV sin | T1 | T2 | T1c | mrag

Dregan
Uzelac
3754

Examination: TREATMENT
Plan: Plan1, TMR 10, 47 min
Target: A:mrag, 20 Gy at 50%

1/1

X: 117.3
Y: 72.0
Z: 66.7

AI View 1 (ACT SIN PA 2015-10-28 08:20) y=-72.0mm

AI View 2 (ACT SIN LL 2015-10-28 08:20) x=-117.3mm

Coronal (T1 2015-10-28 09:13)

Reconstructed, y: 72.0

Sagittal (T1 2015-10-28 09:13)

Reconstructed, x: 117.0

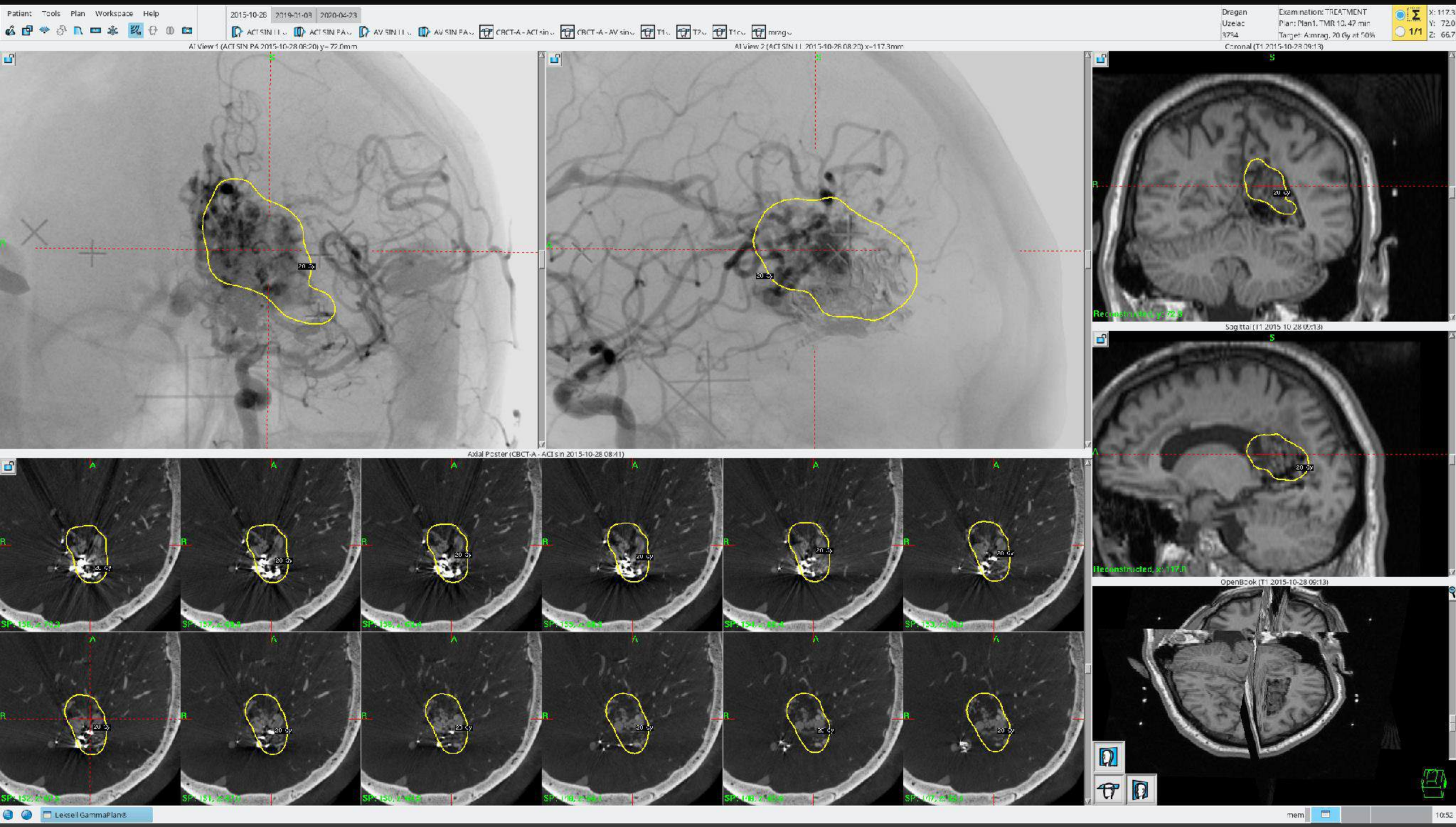
Axial Poster (CBCT-A - ACT sin 2015-10-28 08:41)

OpenBook (T1 2015-10-28 09:13)

Leksell GammaPlan®

mem

10:52



Nidus volume : 8,81 ccm

PD 20 Gy / 50% isodose

Patient Tools Plan Workspace Help

2015-10-28 | 2019-01-03 | 2020-04-23

ACT SIN LL | ACT SIN PA | AV SIN LL | AV SIN PA | CBCT-A - ACT sin | CBCT-A - AV sin | T1c | T2 | T1c | mrag

Dregan
Uzelac
3754

Examination: TREATMENT
Plan: Plan1, TMR 10, 47 min
Target: Asmrag, 20 Gy at 50%

1/1

X: 122.2
Y: 59.6
Z: 71.7

Axial (T1 2015-10-28 09:15)

Axial1 (T1c 2015-10-28 09:27)

Axial2 (CBCT-A - ACT sin 2015-10-28 08:41)

Axial (T2 2015-10-28 09:15)

Axial2 (mrag 2015-10-28 09:30)

Axial3 (CBCT-A - AV sin 2015-10-28 08:49)

SP: 163, z: 72.5

Lekseil GammaPlan®

mem

10:53

Patient Tools Plan Workspace Help

2015-10-28 | 2019-01-03 | 2020-04-23

ACT SIN LL | ACT SIN PA | AV SIN LL | AV SIN PA | CBCT-A - ACT sin | CBCT-A - AV sin | T1c | T2 | T1c | mrag

Dregan
Uzelac
3754

Examination: TREATMENT
Plan: Plan1, TMR 10, 47 min
Target: Asmrag, 20 Gy at 50%

Σ
1/1

X: 122.2
Y: 59.6
Z: 71.7

Axial (T1 2015-10-28 09:15)

Axial1 (T1c 2015-10-28 09:27)

Axial2 (CBCT-A - ACT sin 2015-10-28 08:41)

Axial* (T2 2015-10-28 09:15)

Axial*2 (mrag 2015-10-28 09:30)

Axial*3 (CBCT-A - AV sin 2015-10-28 08:49)

SP: 32, z: 71.3

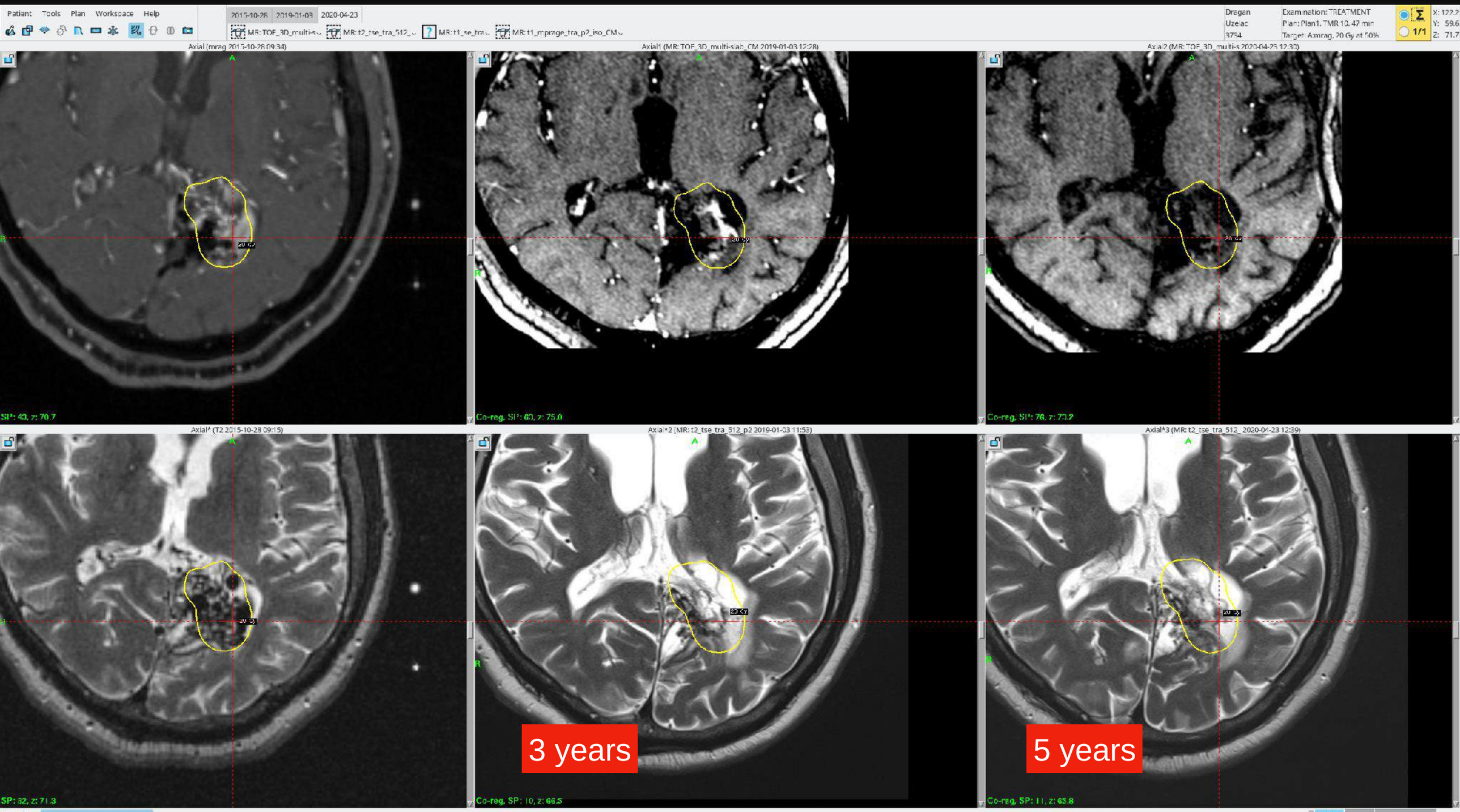
SP: 43, z: 70.7

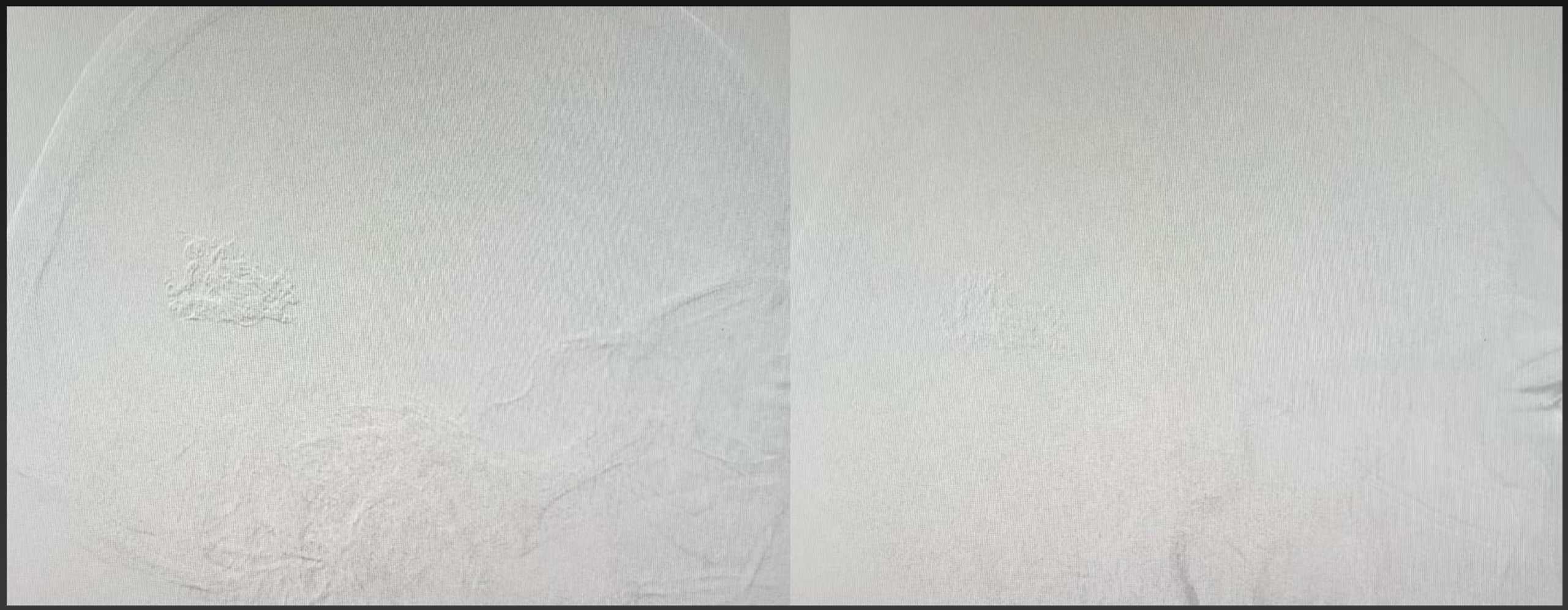
SP: 163, z: 72.5

Leksell GammaPlan®

mem

10:53


3 years
5 years



DSA verification of complete obliteration, 5 yrs after GKRS

Conclusion

- Radiosurgery is a safe, efficient treatment method for bAVMs
- indications should be based on an interdisciplinary agreement
- factors correlating with higher occlusion
- size (volume)
- eloquence / critical structures
- (bleeding status, age)