SRS for Trigeminal Neuralgia and Epilepsy

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Frontiers of Radiosurgery

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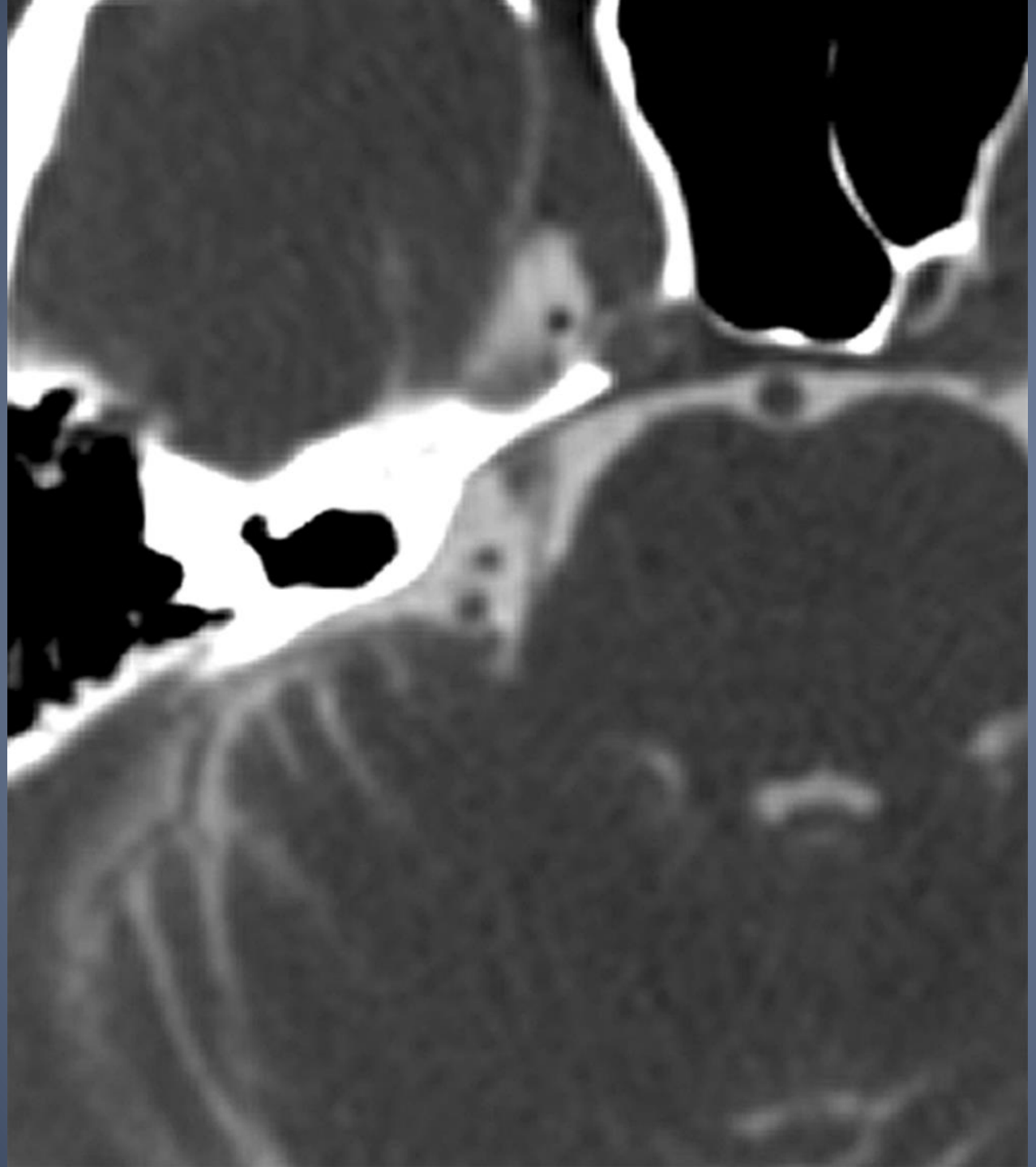
LIFE FROM INSIDE

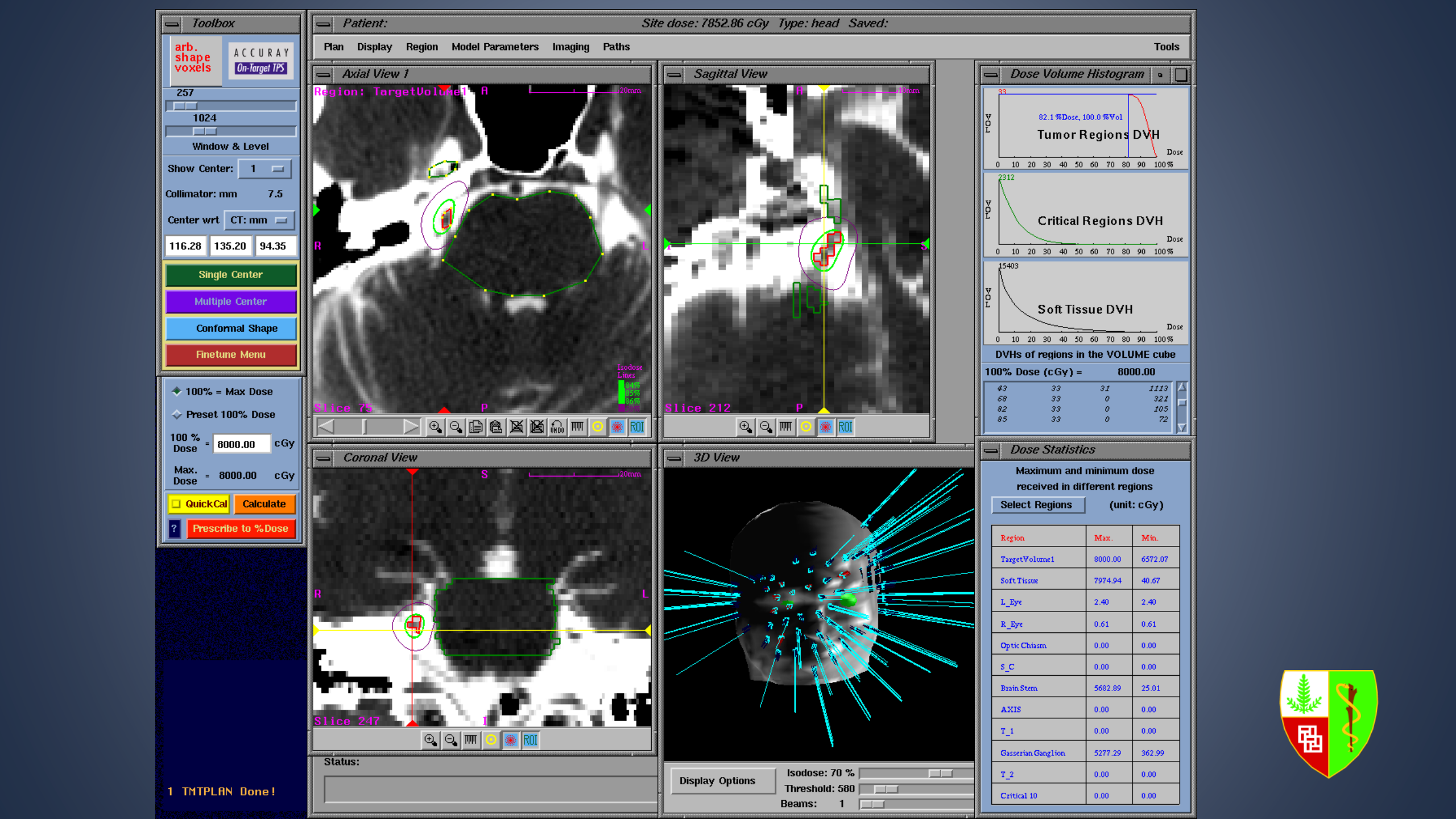
Role of SRS in the treatment of TN

- SRS was developed by Lars Leksell to treat TN and other functional brain disorders
- GK has been used for over 30 years with well established results
- CK, starting from 2001, has introduced novel treatment modalities(frameless non-isocentric homogenous treatment of an elongated segment of the nerve)
- Frameless image-guided SRS is the less invasive non-medical treatment for TN

Cyberknife Image-guided Robotic Radiosurgery

- Developed by John Adler at Stanford
- Non-isocentric inverse treatment planning
- Real-time image-guidance based on DRR
- Robotic delivery by a light-weight Linac
- First TN treatment done at Stanford in 2001
- Standardized CKRS TN protocol implemented at CDI since 2009
- Retrogasserian target 60 Gy-6 mm
- Over 500 cases treated at CDI over a decade
- Long-term prospective follow-up published on Neurosurgery

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Soft Tissue DVH
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82 33 0 105
85 33 0 72
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(unit: cGy)
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R_Eye | 0.61 | 0.61
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S_C | 0.00 | 0.00
Brain Stem | 5682.89 | 25.01
AXIS | 0.00 | 0.00
T_1 | 0.00 | 0.00
Gasserian Ganglion | 5277.29 | 362.99
T_2 | 0.00 | 0.00
Critical 10 | 0.00 | 0.00

Meet Am Soc Stereotact Funct Neurosurg, New York, N.Y., 2003
Stereotact Funct Neurosurg 2003;81:105–109
DOI: 10.1159/000075112

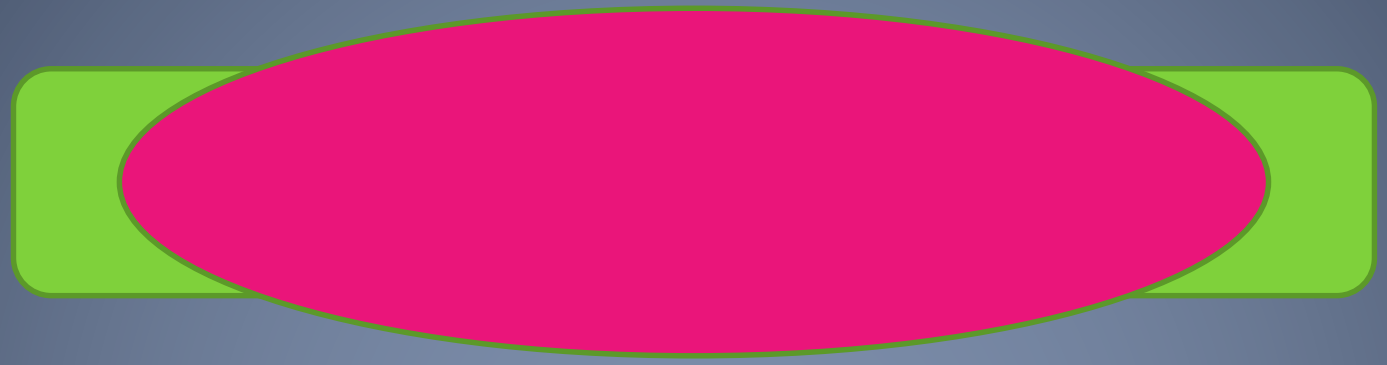
Stereotactic and Functional Neurosurgery

Cyberknife Radiosurgery for Trigeminal Neuralgia

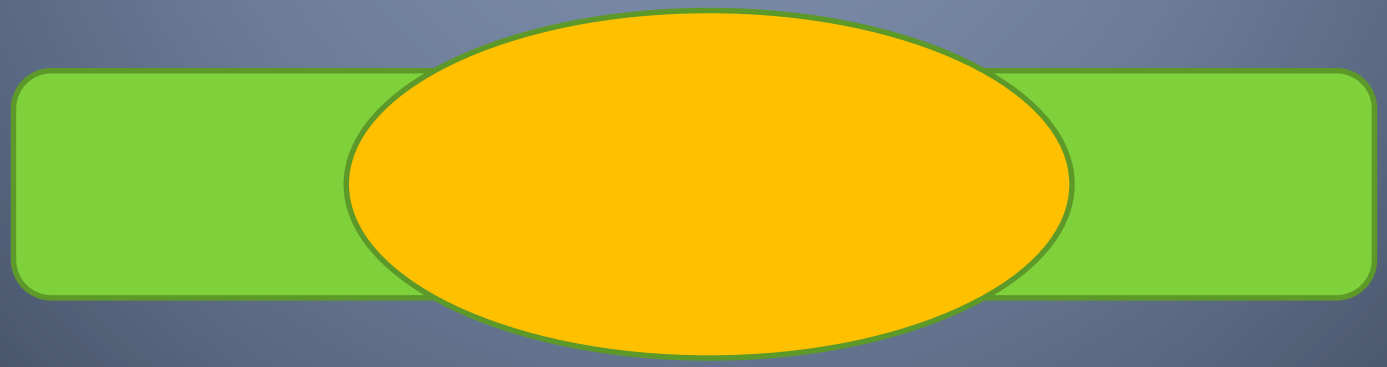
Pantaleo Romanelli Gary Heit Steven D. Chang Dave Martin
Christopher Pham John Adler

Department of Neurosurgery, Stanford University Medical Center,
Stanford, Calif., USA

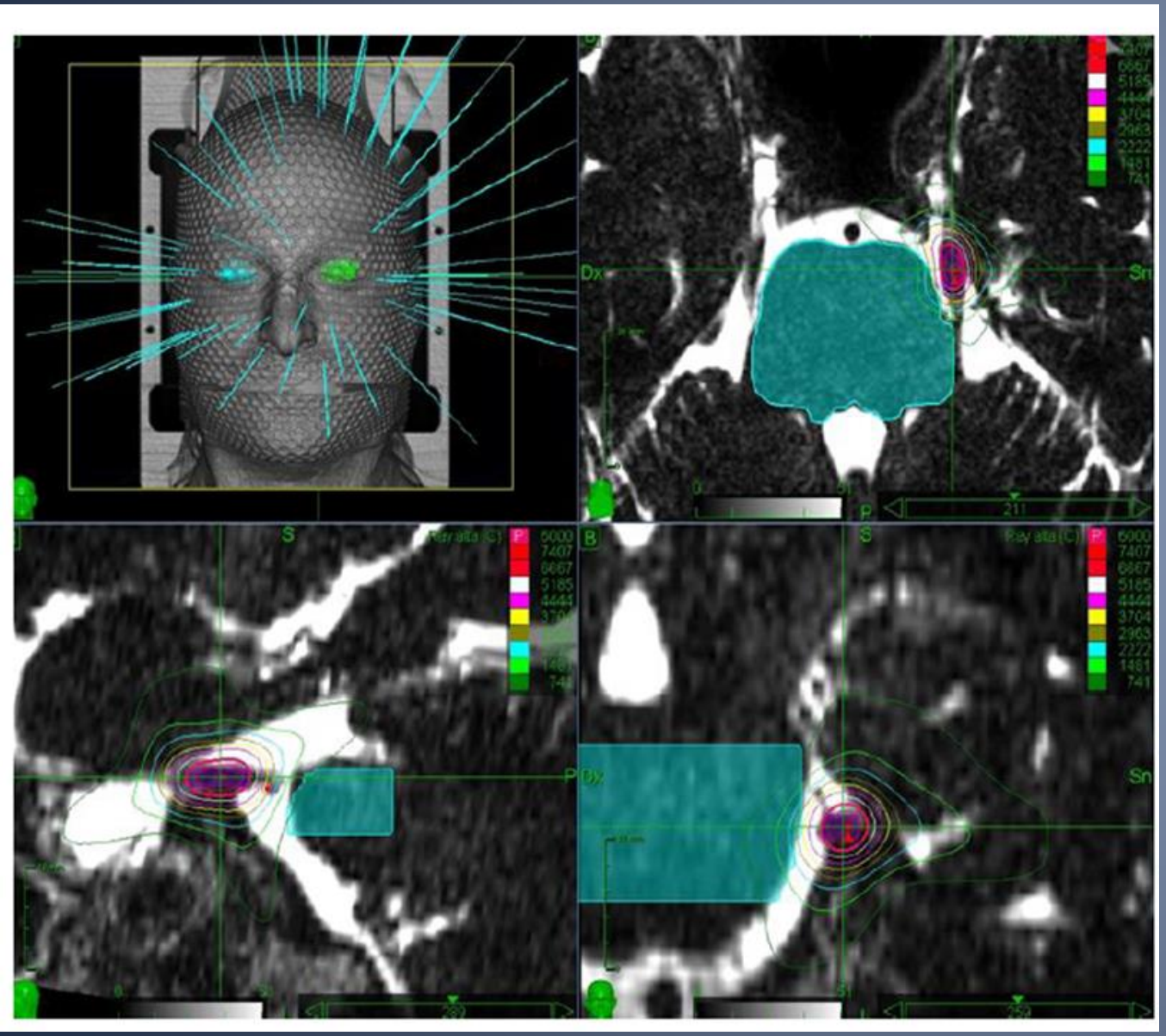
70 Gy @10 mm, Dmax up to 87 Gy



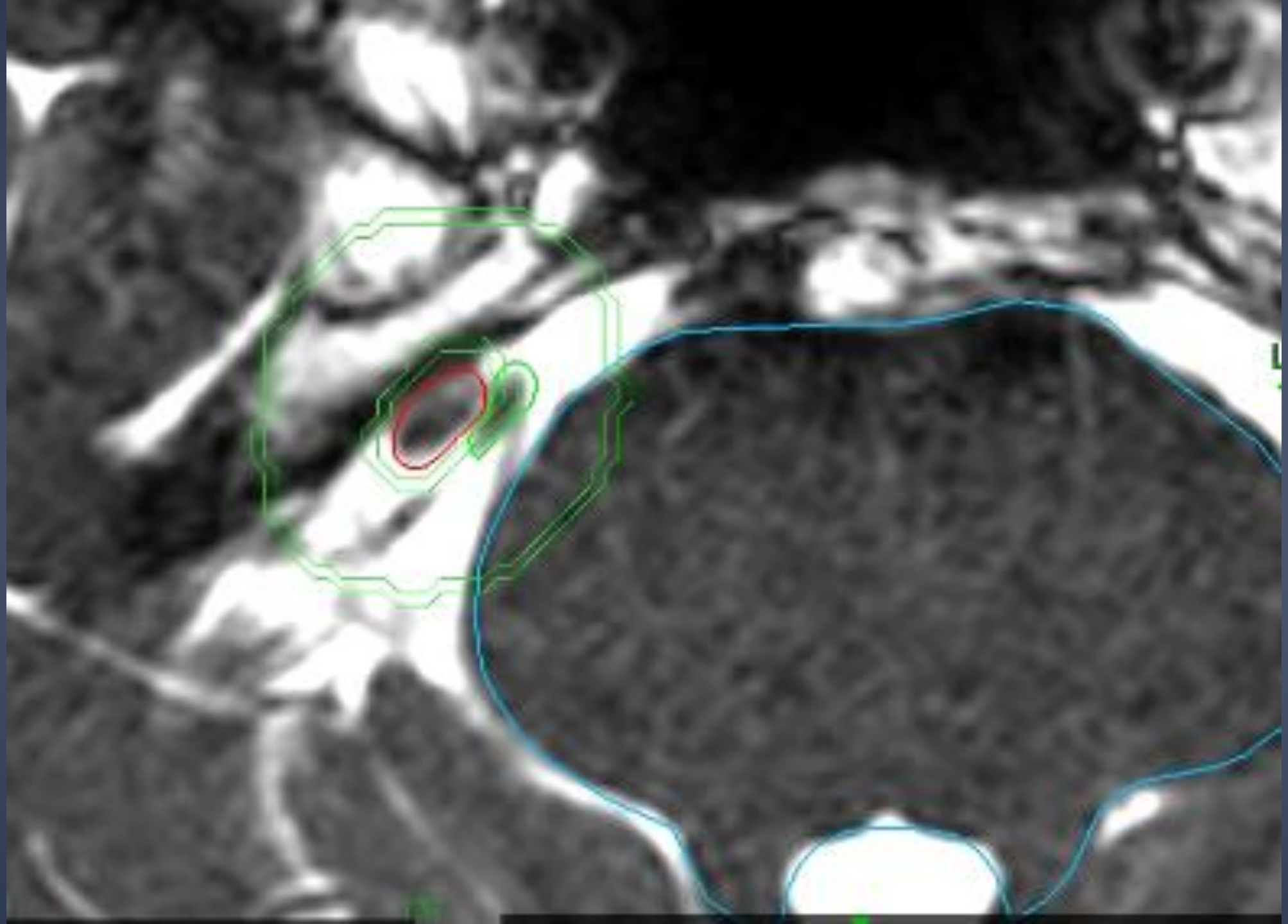
60 Gy @ 6 mm, Dmax < 75 Gy



Target and MR follow-up



Retrogasserian target, 6 mm,60 Gy



Sparing of the motor root

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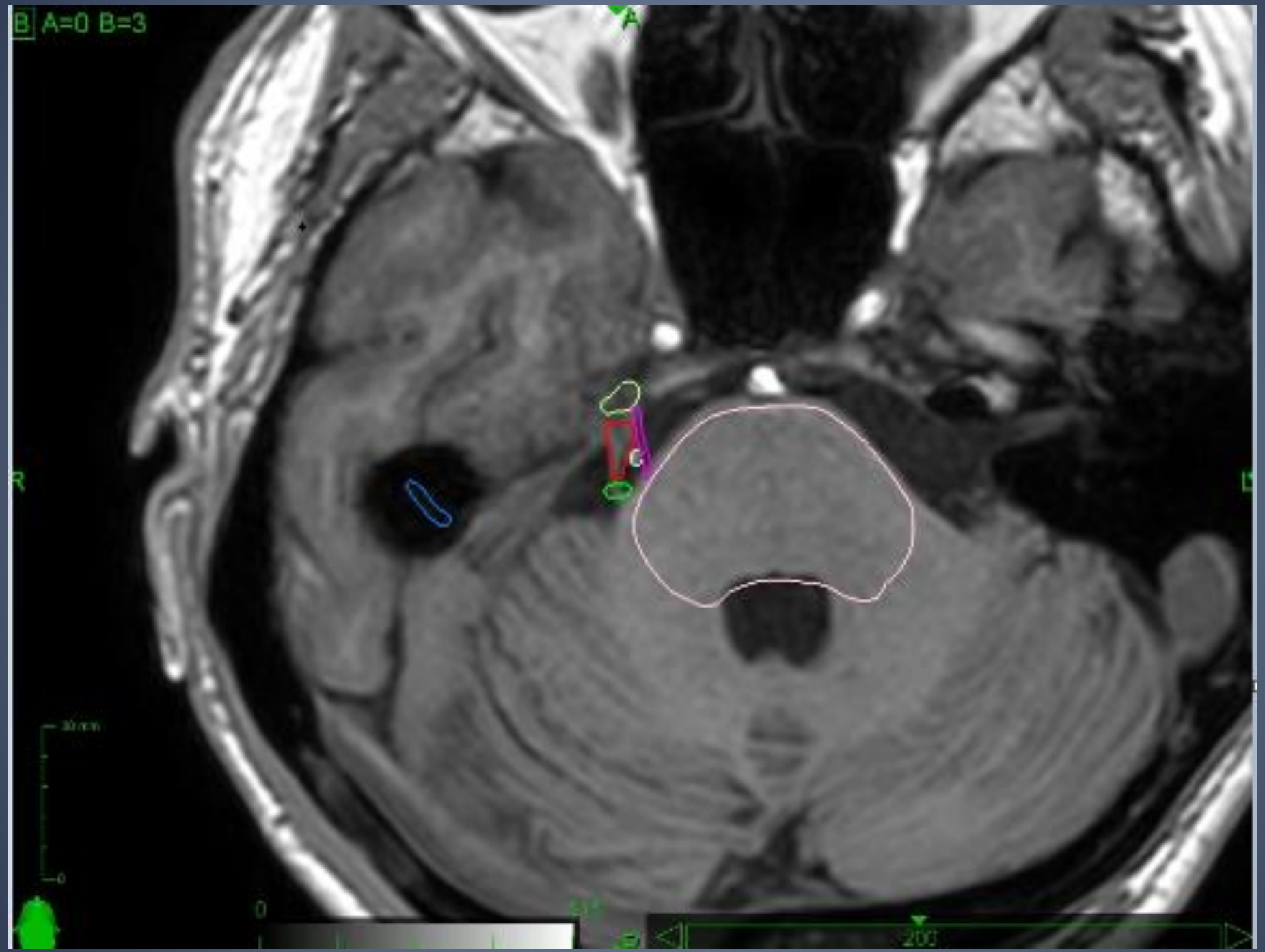
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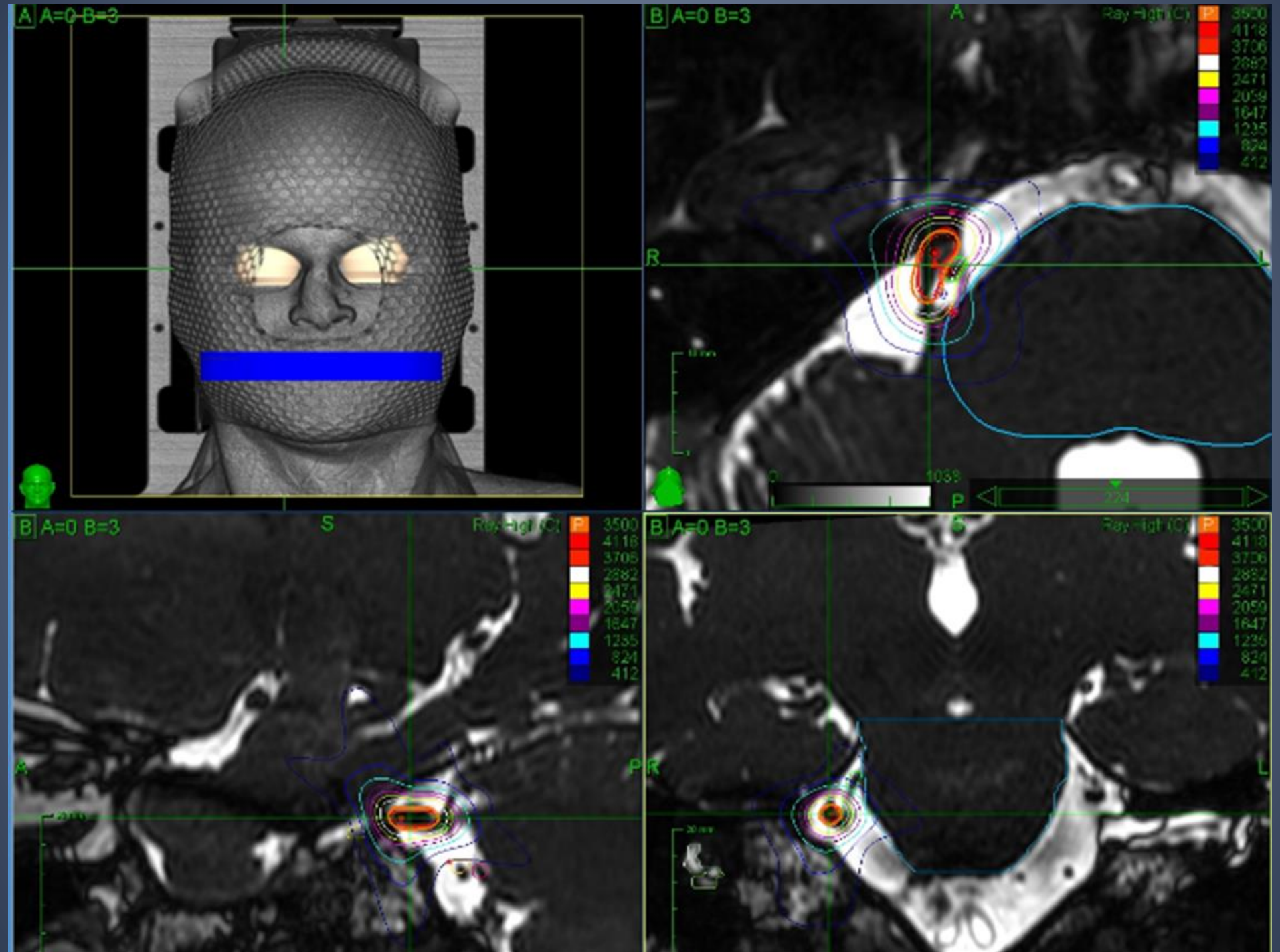
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NEUROSURGERY

Image-Guided Robotic Radiosurgery for Trigeminal Neuralgia

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BACKGROUND: Frameless, non-isocentric irradiation of an extended segment of the trigeminal nerve introduces new concepts in stereotactic radiosurgery for medically resistant trigeminal neuralgia (TN).

OBJECTIVE: To report the results of the largest single-center experience about image-guided robotic radiosurgery for TN.

METHODS: A cohort of 138 patients treated with CyberKnife® (Accuray Incorporated, Sunnyvale, California) radiosurgery with a minimum follow-up of 36 mo were recruited. Pain relief, medications, sensory disturbances, rate and time of pain recurrence were prospectively analyzed.

RESULTS: Median follow-up was 52.4 mo; median dose 75 Gy; median target length 5.7-mm; median target volume 40 mm^3; median prescription dose 60 Gy (80% isodose line). Actuarial pain control rate (Barrow Neurological Institute [BNI] class I-IIIa) at 6, 12, 24, and 36 mo were 93.5%, 85.8%, 79.7%, and 76%, respectively. Overall, 33 patients (24%) required a second treatment.

Overall, 18.1% developed sensory disturbances after 16.4 ± 8.7 mo. One patient (0.7%) developed BNI grade IV dysfunction; 6 (4.3%) developed BNI grade III (somewhat bothersome) hypoesthesia after retreatment; BNI grade II (not bothersome) hypoesthesia was reported by 18 patients (11 after retreatment). Shorter nerve length (<6 mm vs 6 mm), smaller nerve volume (<30 mm^3 vs >30 mm^3), and lower prescription dose (<58 vs >58 Gy) were associated with treatment failure ($P = .01$, $P = .02$, $P = .03$, respectively). Re-irradiation independently predicted sensory disturbance ($P < .001$).

CONCLUSION: Targeting a 6-mm segment of the trigeminal nerve with a prescribed dose of 60 Gy appears safe and effective. Persistent pain control was achieved in most patients with acceptable risk of sensory complications, which were typically found after re-irradiation.

KEY WORDS: Trigeminal neuralgia, Pain, Stereotactic radiosurgery, Robotic, Image-guided, CyberKnife

A cohort of 138 TN patients treated with CyberKnife®radiosurgery prospectively followed for 5 y

Follow-up time points: 6 Weeks,3-6-9-12-18-24-48-54-60 Months

Pain relief, Medications, Sensory Disturbances, Rate and Time of Pain Recurrence

BNI

Score	Pain description
I	No pain, no medications
II	Occasional pain, no medications required
III	Some pain, adequately controlled with medications
IV	Some pain, not adequately controlled with medications
V	Severe pain or no pain relief

NRS

Rating	Pain Level
0	No Pain
1–3	Mild Pain (nagging, annoying, interfering little with ADLs)
4–6	Moderate Pain (interferes significantly with ADLs)
7–10	Severe Pain (disabling; unable to perform ADLs)

Median follow-up was 52.4 months(range: 36 - 80 months) .

Median prescription dose was 60 Gy (@80% isodose line).
Median maximum dose was 75 Gy.
Median target length: 5.7 mm.
Median target volume: 40 mm^3.

BNI numbness

Score 1: No facial numbness
Score 2: Mild facial numbness, not bothersome
Score 3: Mild facial numbness, somewhat bothersome
Score 4: Mild facial numbness, very bothersome

Age/Sex	Mean 57.8 years 79F/59M
Type of Neuralgia	TN1 (typical) 124 (89.8%) TN2 (atypical) 14 (11.2%)
Pathology	Multiple sclerosis 6 (4.3%) Neurovascular conflict 87 (63%)
Pain Distribution	
Left	62%
Right	38%
V1	-
V2	33 (23.9%)
V3	29 (21%)
V1-V2	12 (8.7%)
V2-V3	51 (37%)
V1-V2-V3	13 (9.4%)
Average Time from Onset	4.3 years
BNI Pain Score	
IIIb	-
IV	27 (19.6%)
V	111 (80.4%)
NRS Score	
10	51 (37%)
9	44 (31.9%)
8	22 (15.9%)
7	20 (14.5%)
6	1 (0.7%)
Previous Treatments	Percutaneous Rhizotomy 12 (8.6%) MVD 2 (1.4%)

Results

Actuarial pain control rate (Barrow Neurological Institute [BNI] class I-IIIa) at 6, 12, 24, and 36 months were 93.5%, 85.8%, 79.7%, and 76%, respectively.

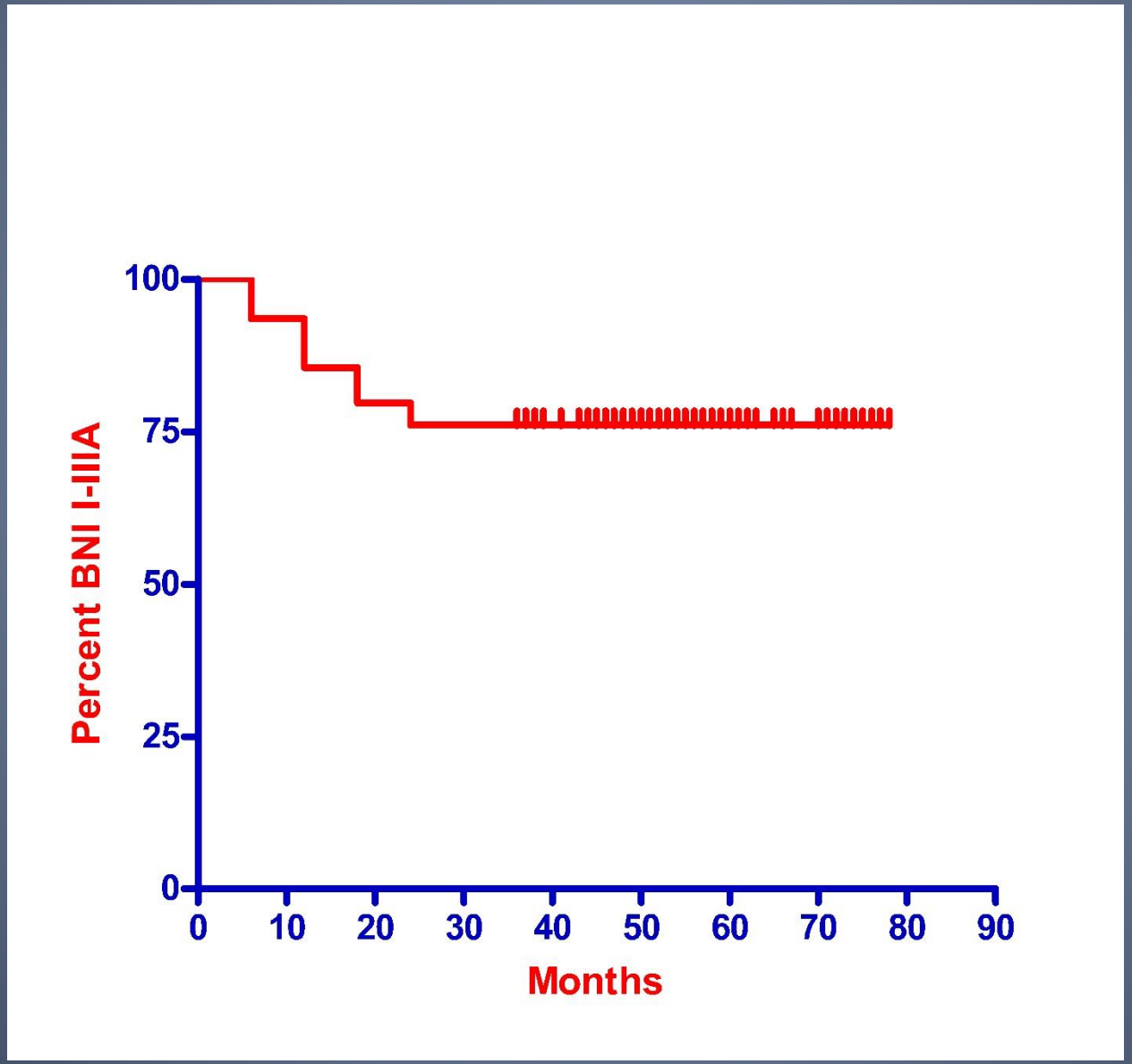
Median time for pain relief: 3 weeks(range 1-20 w).

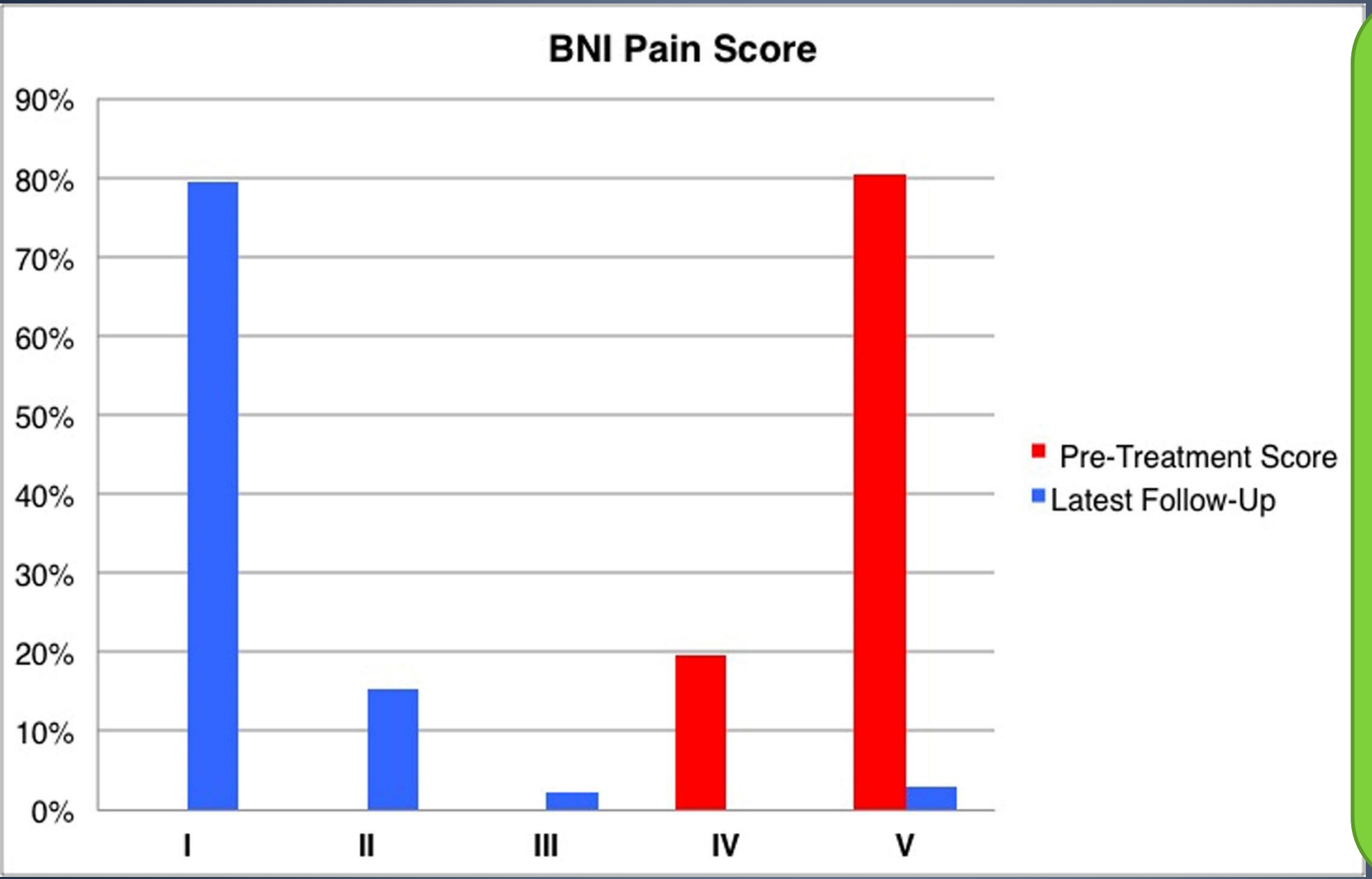
Shorter nerve length (<6 mm vs. 6 mm), smaller nerve volume target (<30 mm^3 versus >30 mm^3) and lower prescription dose (<58 versus>58 Gy) were associated with treatment failure .

33 patients (24%) experienced recurrent pain requiring a second treatment , developing stable pain control thereafter ; median time of recurrence was 13 months.

7 patients (5%) developed bothering paresthesias(BNI grade III-IV). 6/7 received 2 treatments.

Pain control on Kaplan-Meyer plot





Score I
No trigeminal pain, no medication

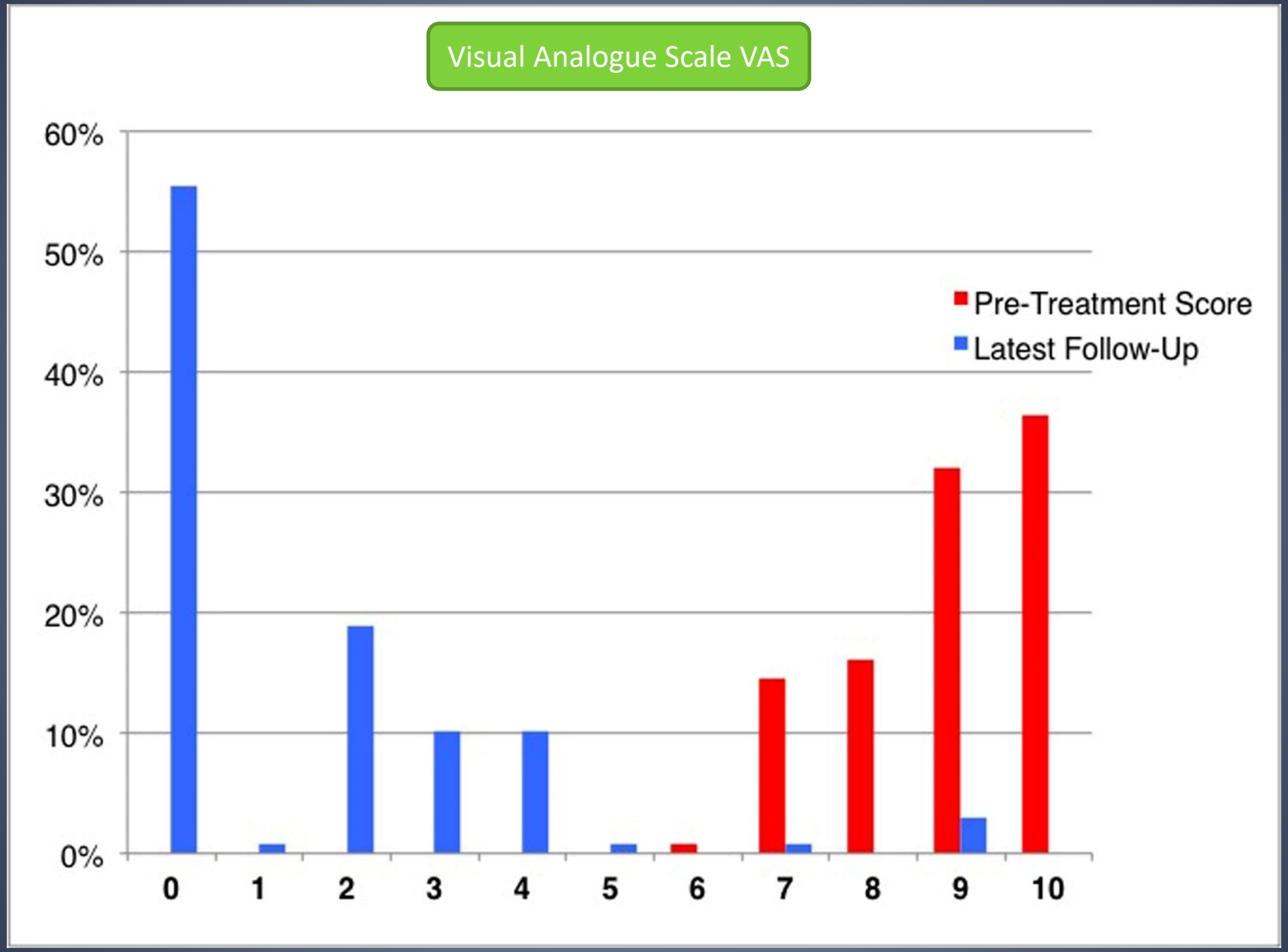
Score II
Occasional pain, not requiring medication

Score III
No pain(IIIa) or some pain(IIIb), adequately controlled with medication

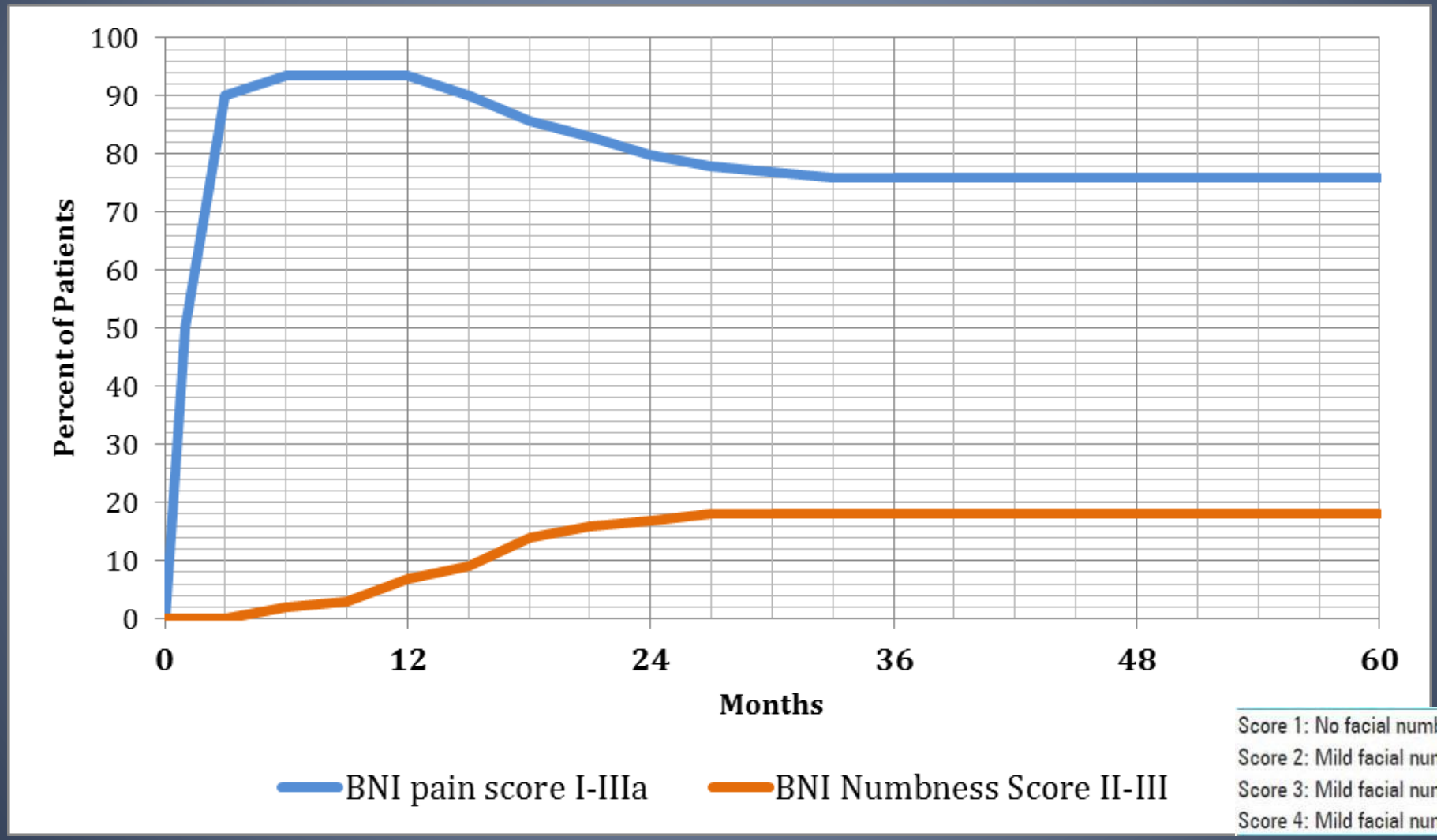
Score IV
Some pain, not adequately controlled with medication

Score V
Severe pain, no pain relief

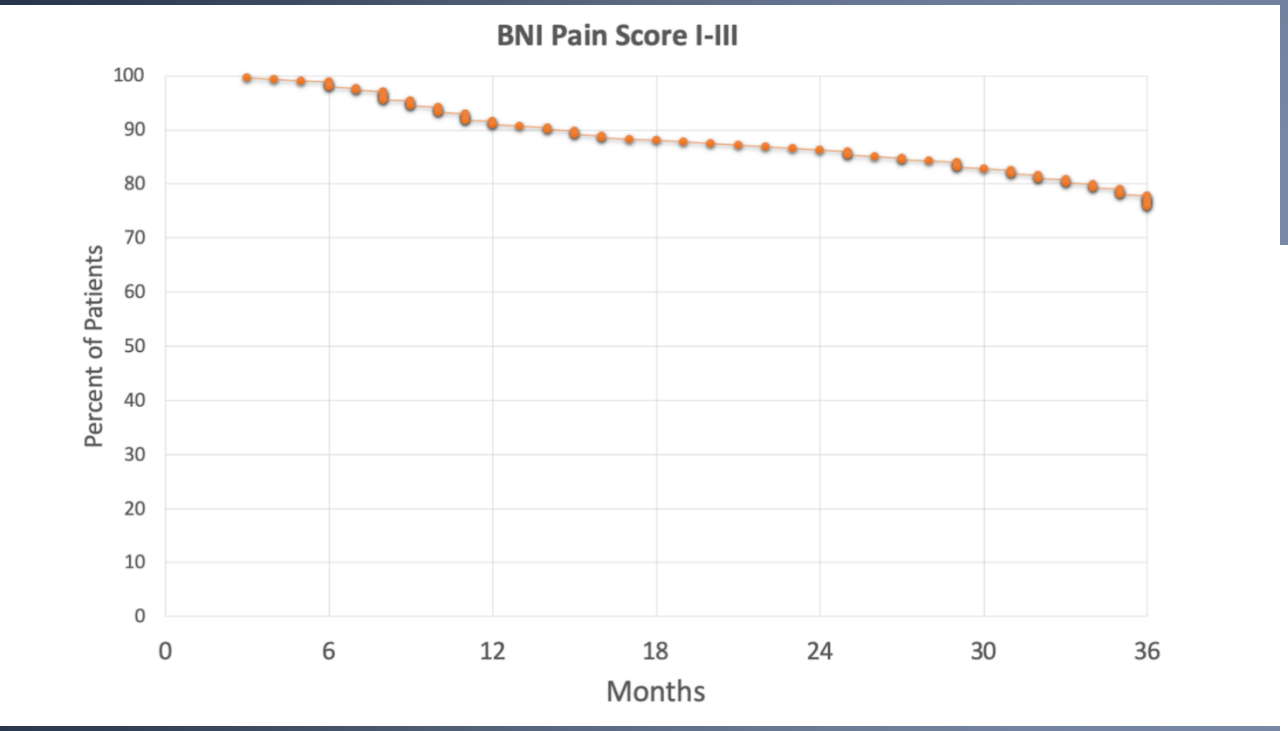
Visual Analogue Scale VAS

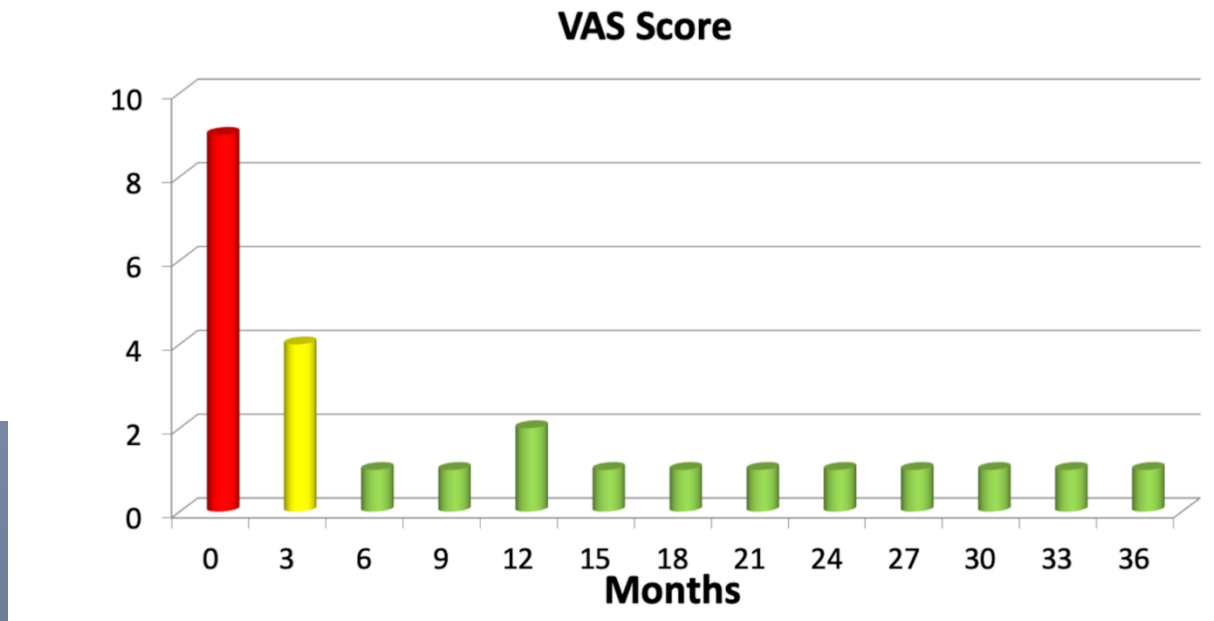


Actuarial rate of pain control and sensory complications @ 5 y



3 y follow-up on 343 pts receiving 387 treatments



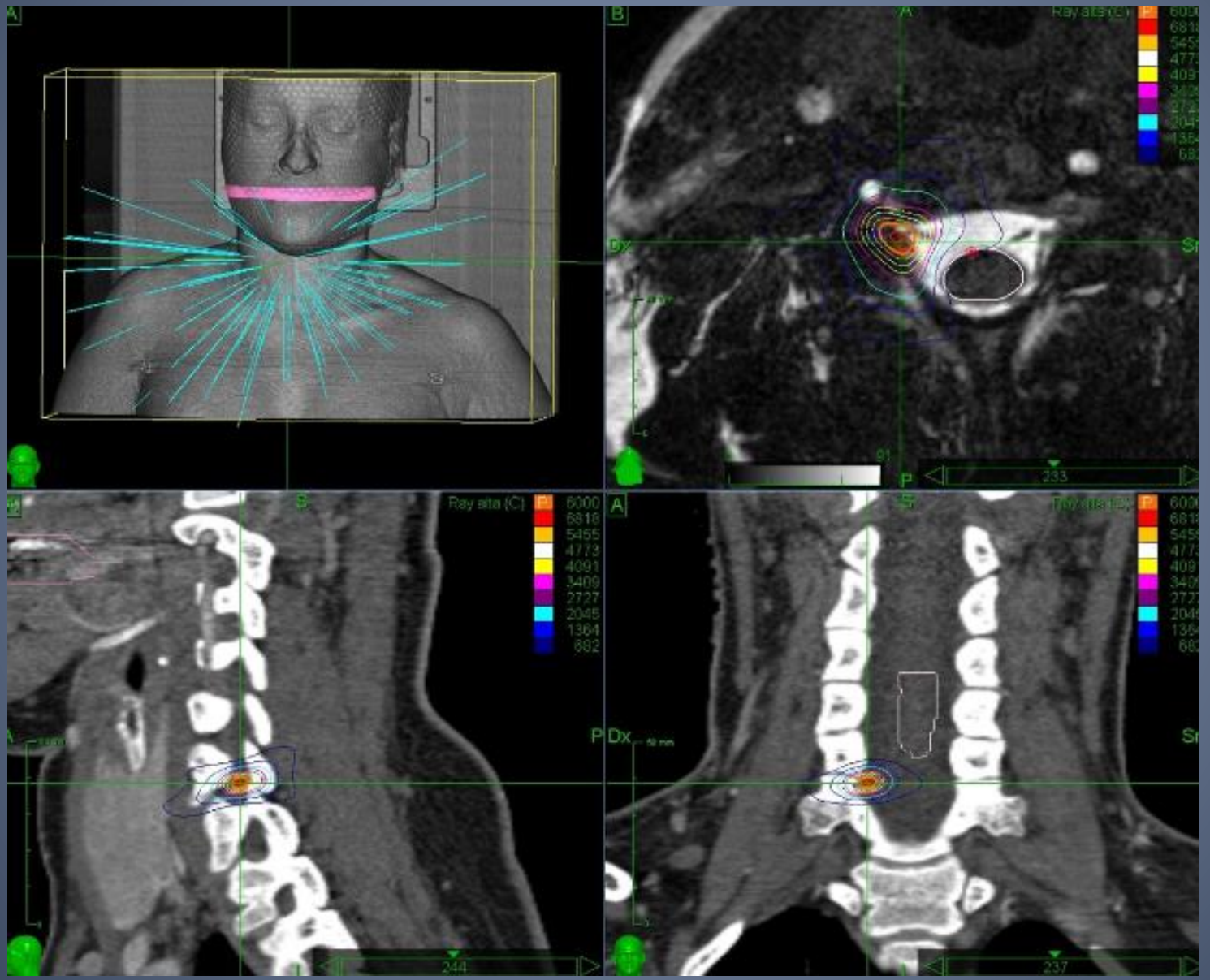


Cyberknife Radiosurgery for Trigeminal Neuralgia
In press, Cureus

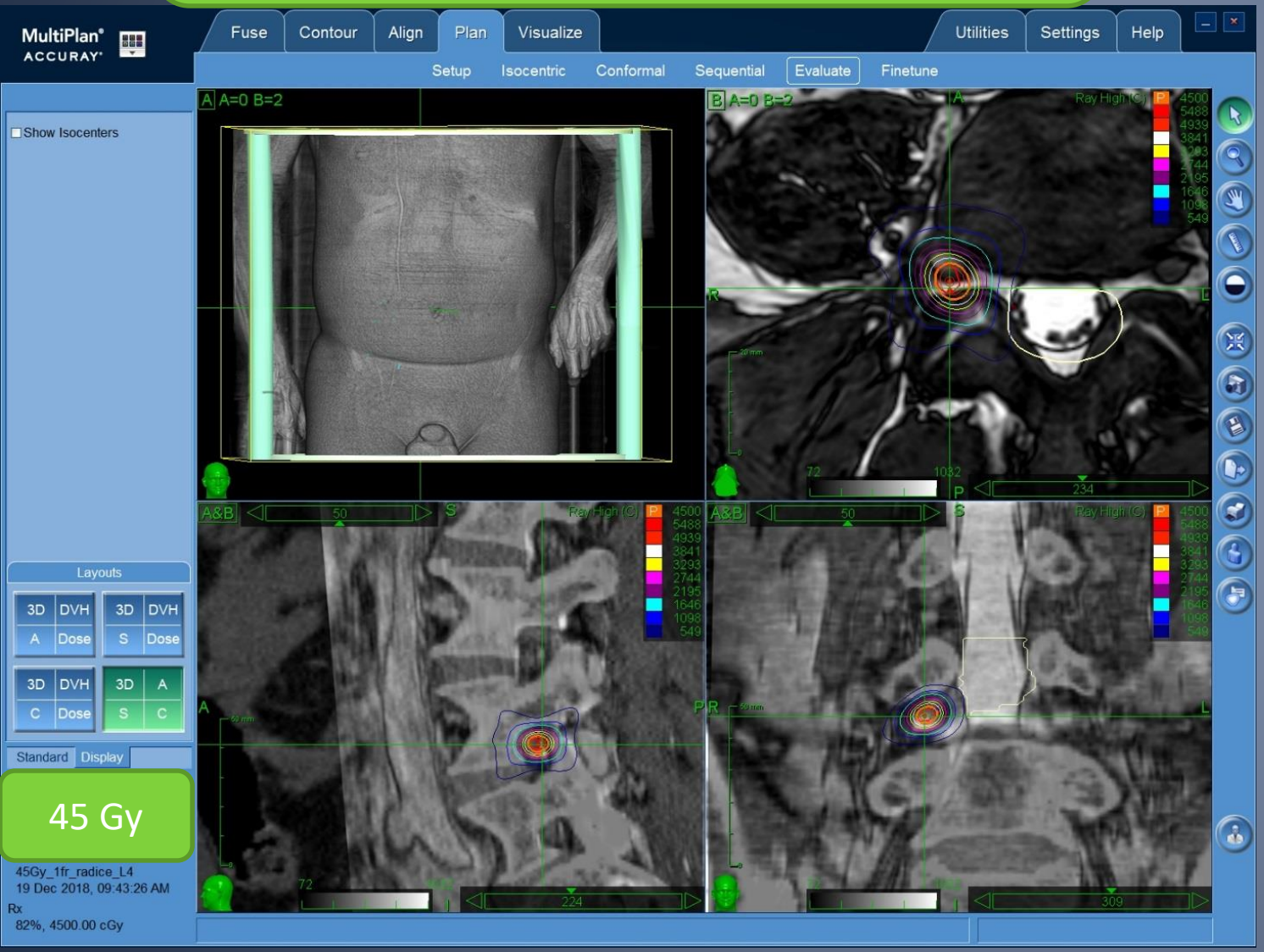
Conclusions

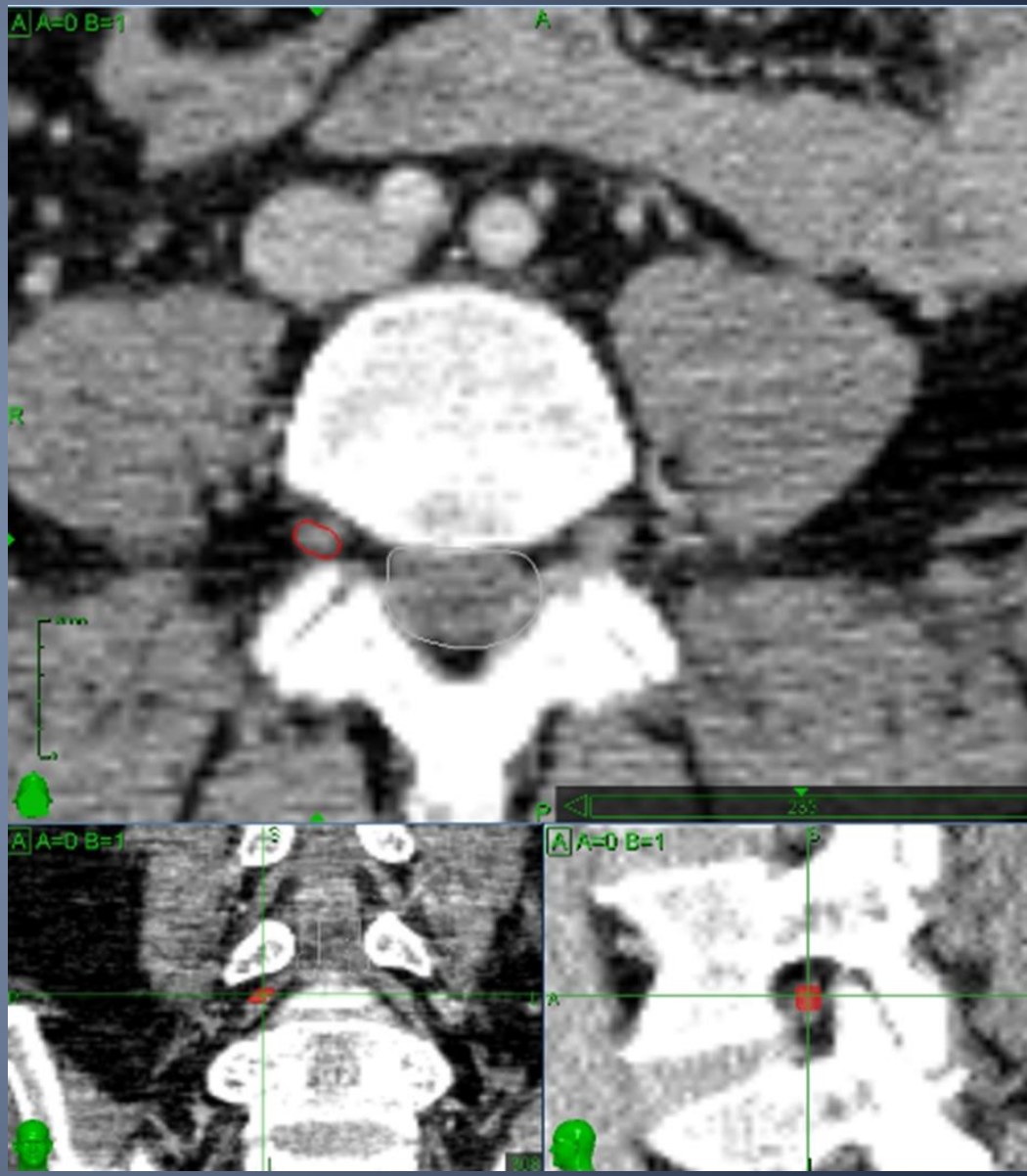
- SRS is an established treatment option for TN
- Frameless image-guided robotic radiosurgery(CK) is safe and effective with encouraging long-term results
- 76% of patients treated pain free @ 5 y with 5% rate of sensory complications
- CK is an emerging treatment option for functional disorders affecting the brain but can also be used to treat novel targets , such as the DRG, unreachable by other radiosurgical platforms

Dorsal Root Ganglion Modulation for C6 focal painful dystonia



L4 root modulation for spasticity following repeated brain and spinal procedures





Radiosurgery for epilepsy

Lancet Neurol 2006; 5: 613–20

Pantaleo Romanelli, David J Anschel

Radiosurgery is an emerging therapeutic approach for the treatment of medically intractable epileptogenic foci. A favourable seizure outcome was first reported in studies of the effects of radiosurgery in the treatment of arteriovenous malformations and tumours. Radiosurgery has since been applied to the treatment of complex partial seizures with mesial-temporal-lobe onset. Nearly simultaneously, experimental evidence supporting the usefulness of radiosurgery to improve or abolish seizures has confirmed that stereotactic irradiation can preferentially affect epileptogenic versus normal cortex. Further work is clearly needed, but this technique might become an important approach in the management of mesial-temporal and extratemporal epilepsy, especially if refractory seizures arise from eloquent cortex or surgically challenging regions of brain.

SRS offers an attractive novel option for the treatment of drug-refractory epilepsy providing a non invasive treatment to patients non invasively mapped by MR, PET,SPECT and MEG

CyberKnife® Radiosurgery as First-line Treatment for Catastrophic Epilepsy Caused by Hypothalamic Hamartoma

Pantaleo Romanelli [1]

1. Cyberknife Center, Centro diagnostico italiano, Milano, ITA

Cureus

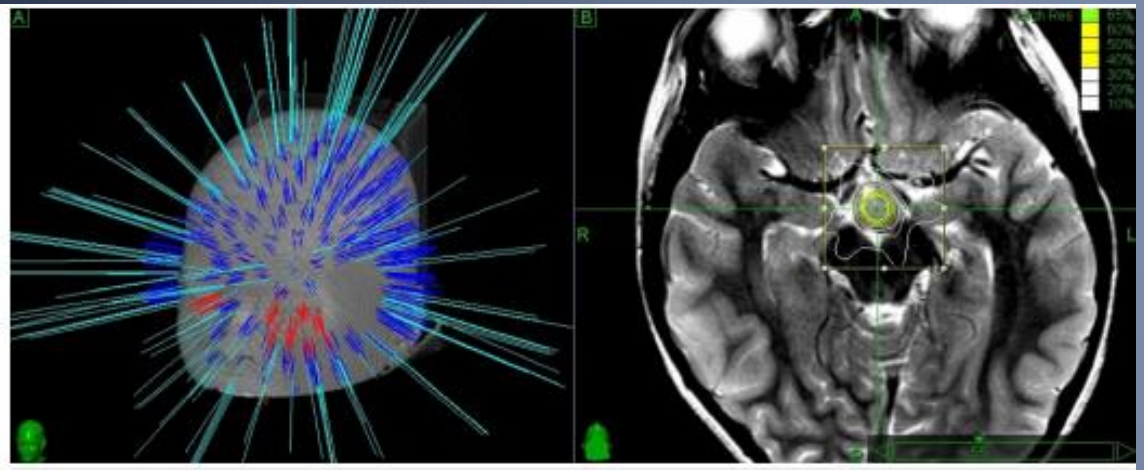


FIGURE 1: Case I.

Left panel shows a 3D simulation of the beam pathways delivering 16 Gy prescribed to the 65% isodose. Frameless delivery allows the penetration of a wide number of beams below the orbito-meatal line.

Right panel shows the isodose distributions on a T2W MR. An interpeduncular hyperintense lesion is visible just posterior to the optic tracts and attached to the mammillary bodies which are compressed, distorted and displaced posteriorly. Optic tracts, brainstem and hippocampi outside the 30% isodose, thus being spared by high-dose irradiation.

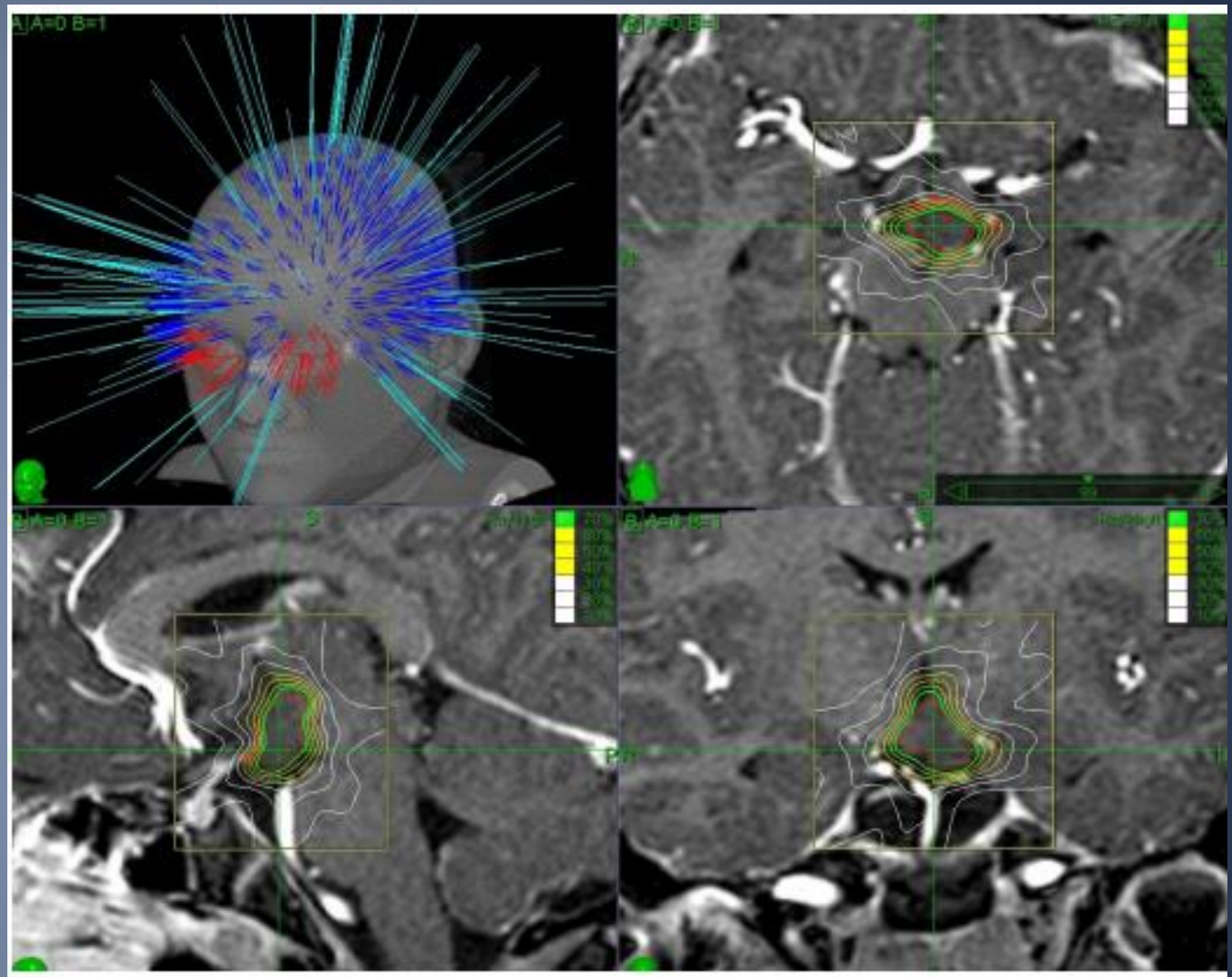


FIGURE 2: Case II.

Treatment planning shown on T1W MR. The non-isocentric beam trajectories are visible on the top left. Isodose curves are visible in the axial, sagittal and coronal planes (top right, bottom left and bottom right, respectively).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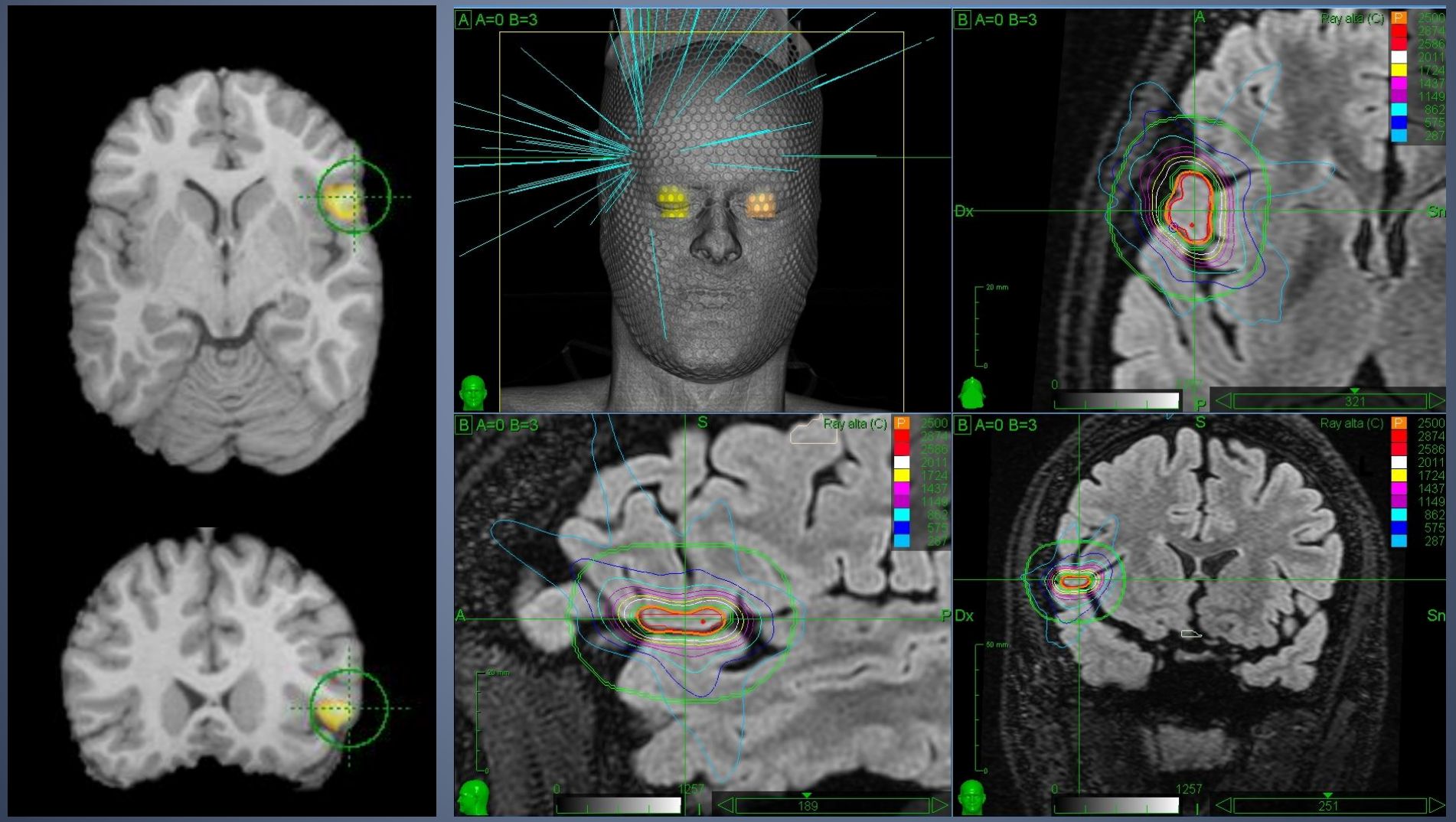
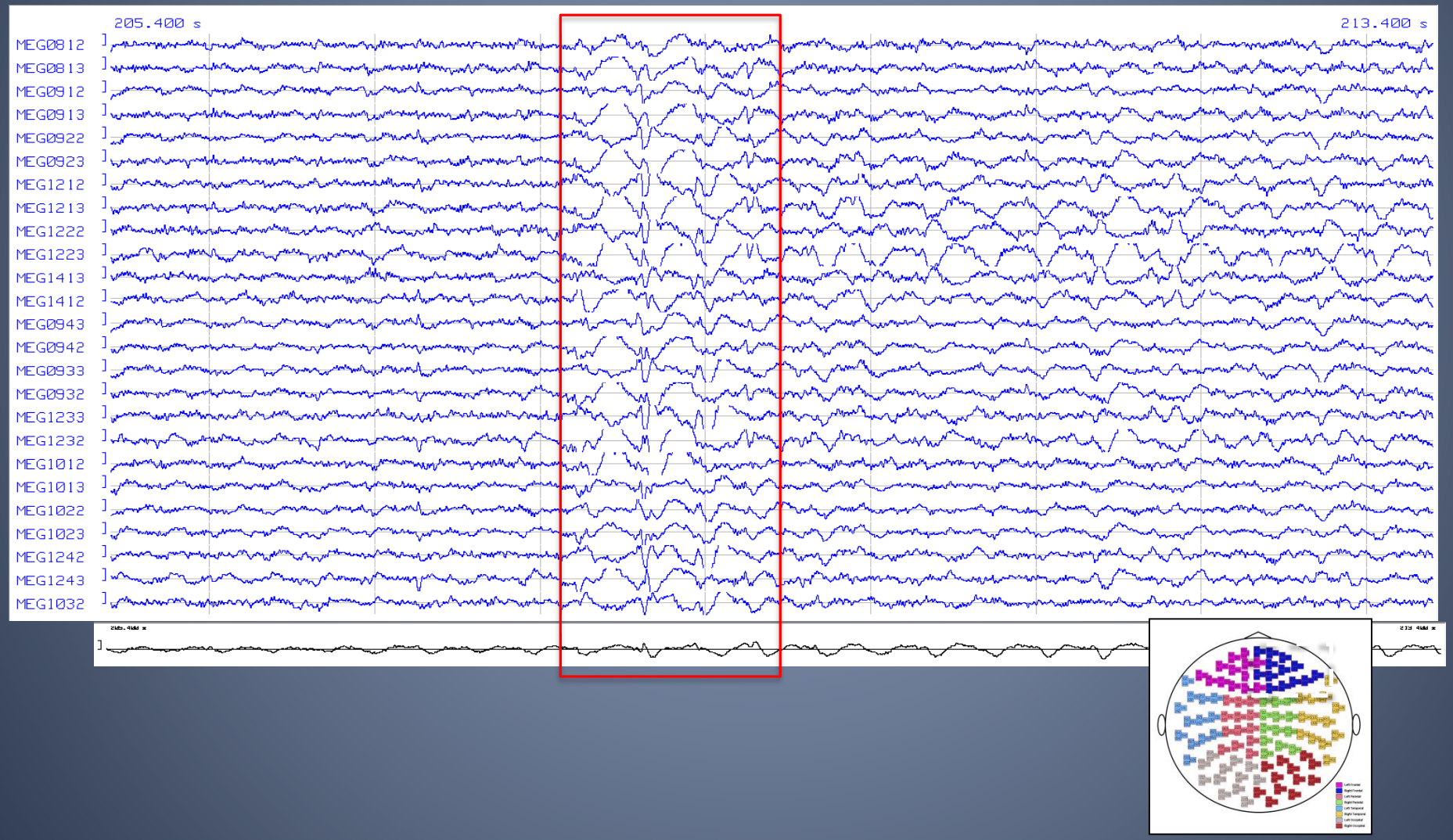
MEG aided SRS for Drug-refractory Epilepsy

26 y old patient with severe focal epilepsy originating from eloquent cortex (Broca)

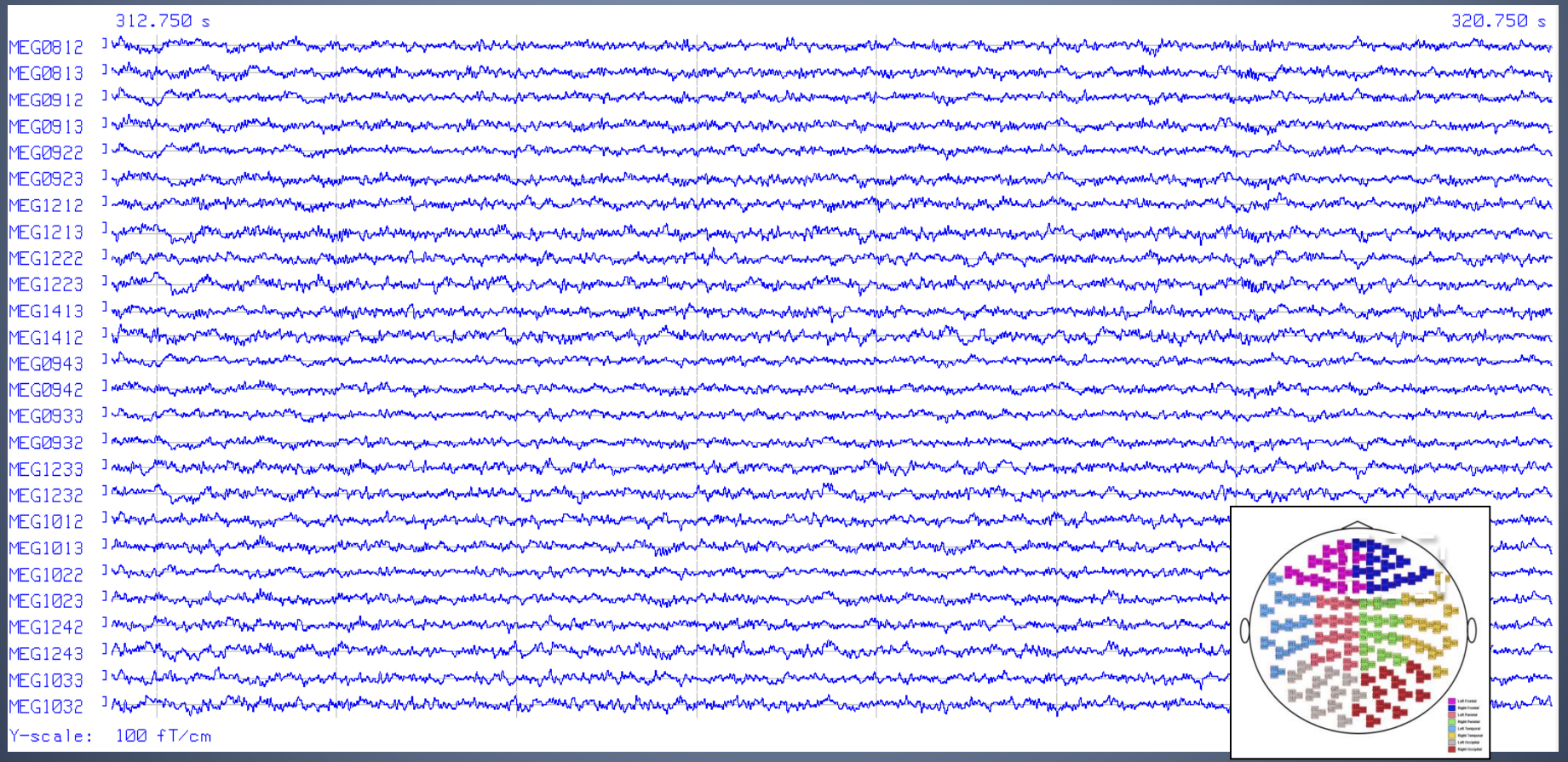


Preoperative MEG

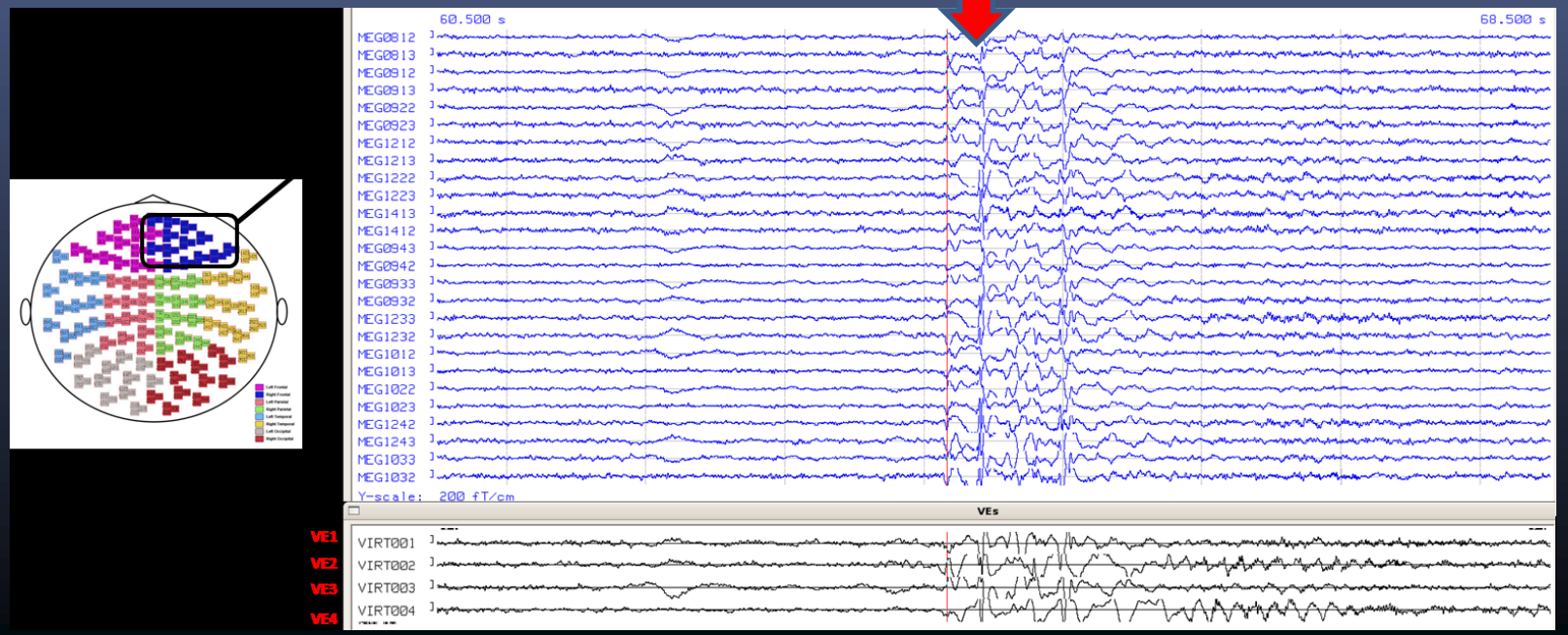


Postoperative MEG

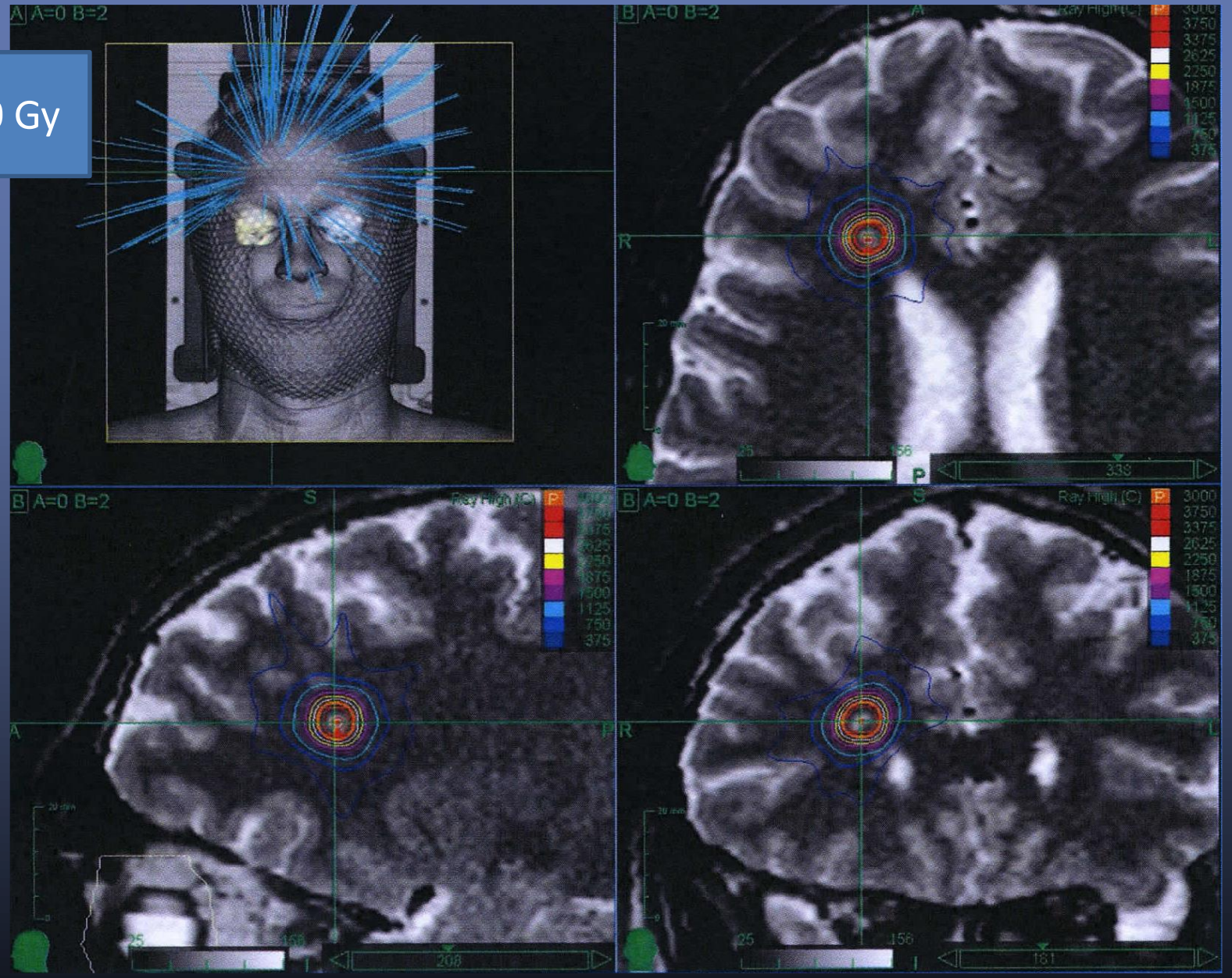
- Patient seizure free since SRS (~64 months)
- Postoperative MEG shows marked improvement



28 y old male with drug-refractory multiple daily CPS.
Judged Not eligible for invasive monitoring



30 Gy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B A=0 B=2
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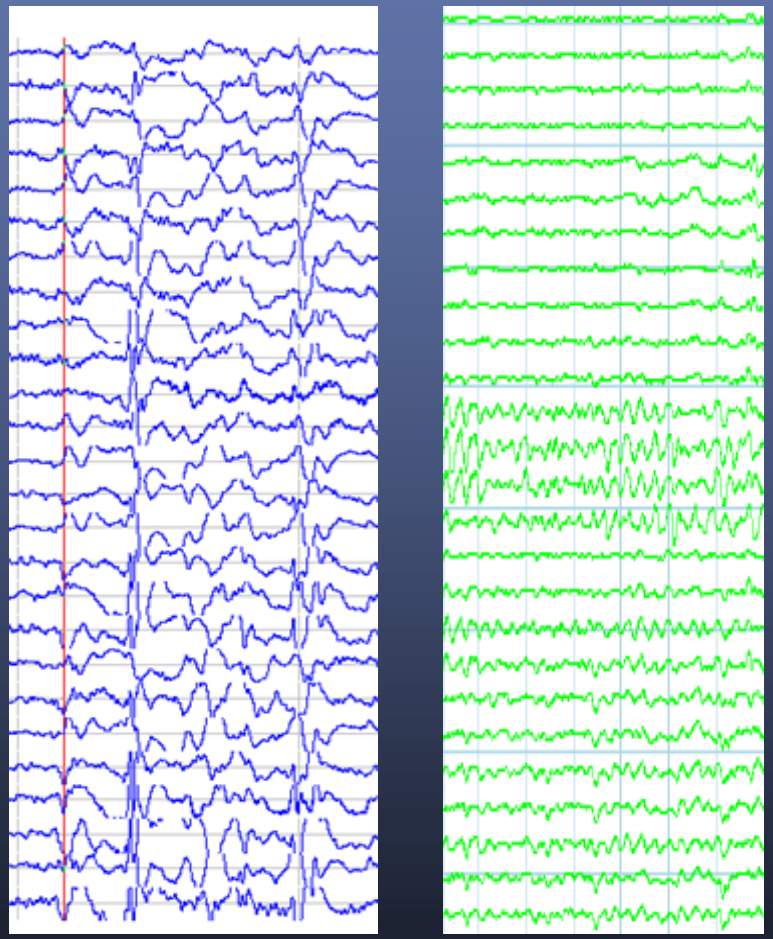
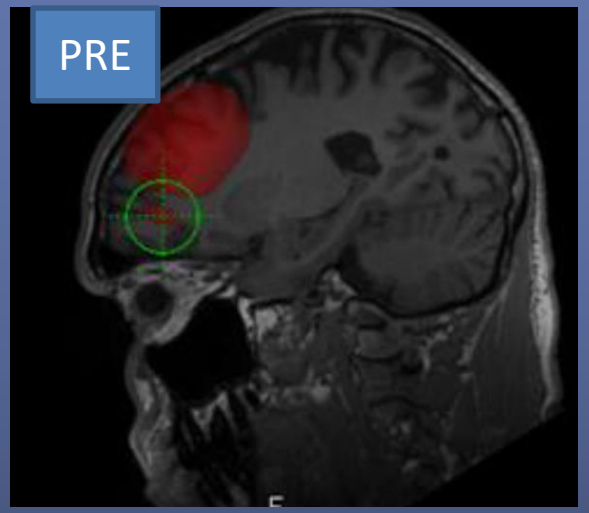
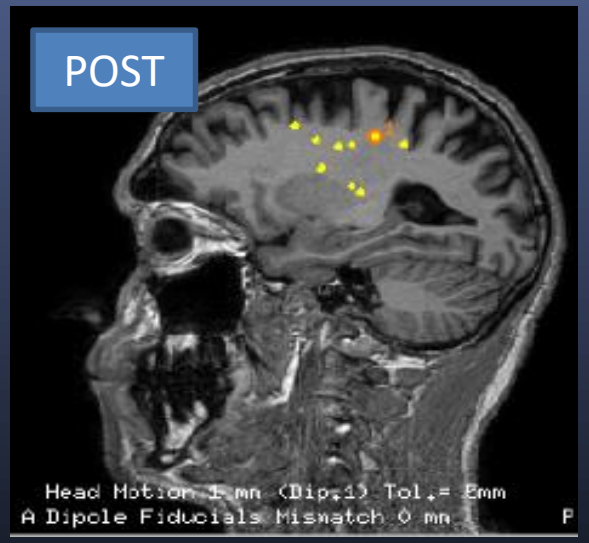
181

Seizure free since the procedure.Follow-up: 56 months.

MEG PRE and 3-m POST







SRS is an Emerging Option for Functional Brain Disorders

SRS is viewed by most as tool to treat tumors

Functional Radiosurgery dedicated to the treatment of TN, epilepsy, spasticity and many other common brain disorders can be a precious cost-effective adjunct to conventional treatments

Deep knowledge of the disease treated ,the anatomy involved and the radiosurgical technique are required

Much more work is needed