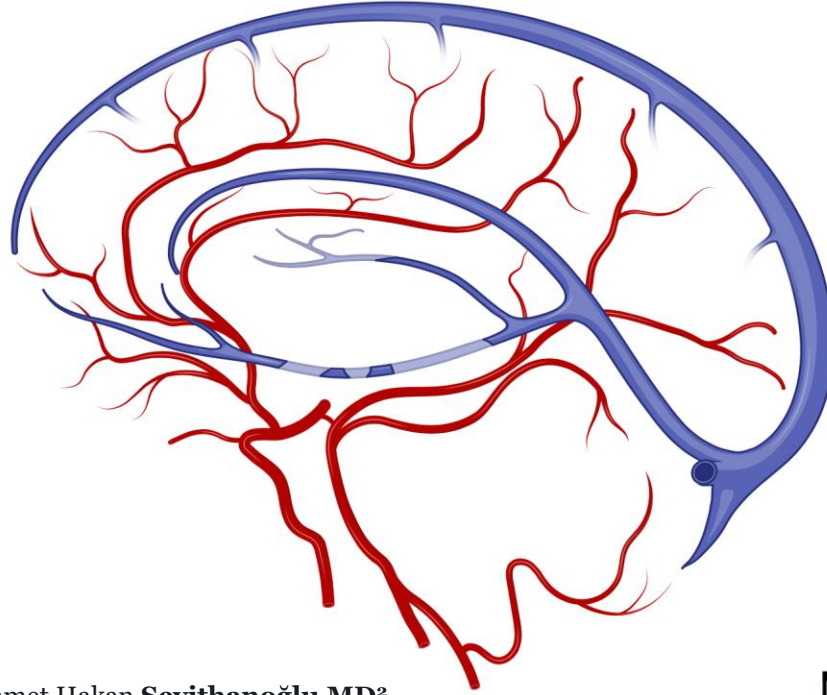


# Gamma Knife Radiosurgery On Arteriovenous Malformations; Efficiency, Outcomes, and Possible Side Effects



Mehmet Denizhan **Yurtluk MS<sup>1</sup>** · Mehmet Hakan **Seyithanođlu MD<sup>2</sup>**

<sup>1</sup>Bezmialem Vakıf University, School Of Medicine, Istanbul/Türkiye

<sup>2</sup>Bezmialem Vakıf University, School Of Medicine, Department Of Neurological Surgery, Istanbul/Türkiye



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# Defining Arteriovenous Malformations

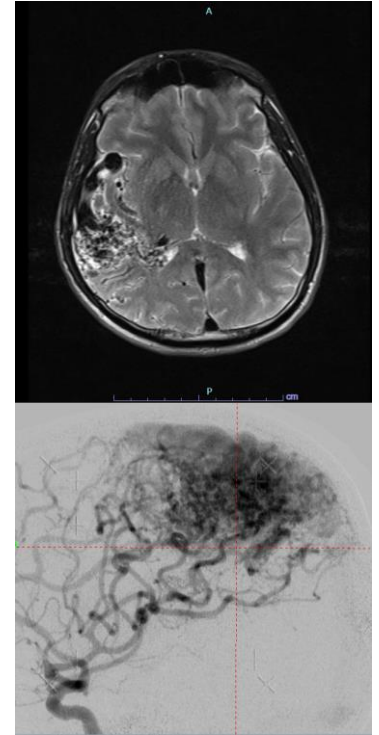
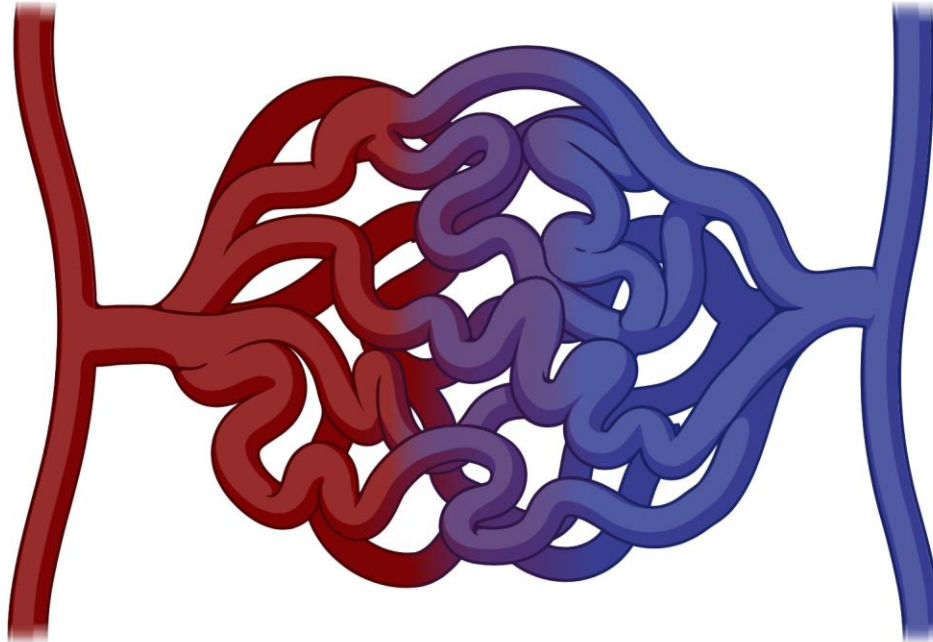
Arteriovenous Malformations (AVM) are congenital, high pressure and velocity shunts between arteries and veins.

Three main components:

- 1) **Feeding artery**
- 2) **Nidus**
- 3) **Draining vein**

Endovascular embolization, microsurgical resection, **stereotactic radiosurgery**, observation.

Digital subtraction angiography (DSA) is the gold standard for diagnosis.

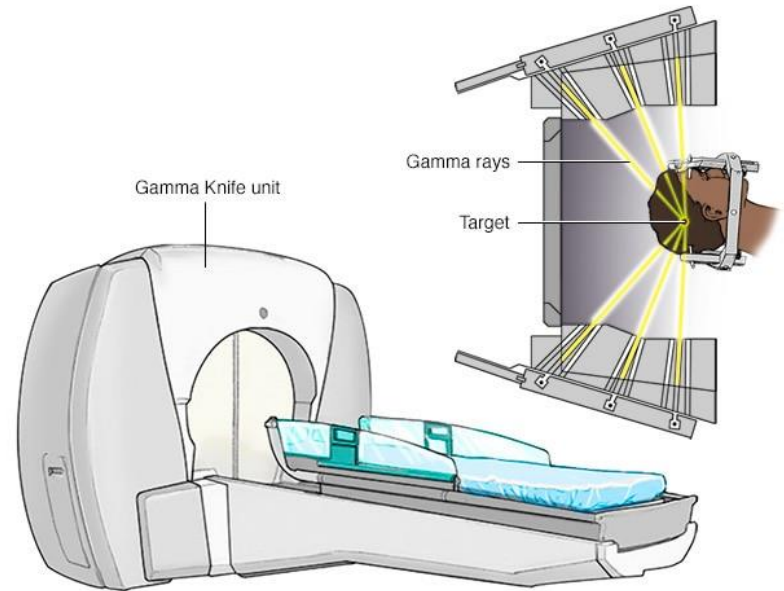


# Gamma Knife Radiosurgery: From Goals to Technique

Gamma Knife Radiosurgery (GKRS) uses very precise gamma rays to target and treat lesions of various pathologies.

GKRS provides treatment efficacy comparable to whole-brain radiation therapy with a decreased risk of adverse radiation effects.

Following stereotactic frame placement under local anesthesia, the patient is taken into the MRI suite for taking post-contrast T1 and T2 images. Then, cerebral angiography was obtained. Treatment was planned with these images integrated into the Leksell GammaPlan® dose planning system.



# Patient Cohort

185 patients with AVM were treated in our Leksell Gamma knife unit between 2014-2023.

Patients with <6 months of follow-up were excluded from the cohort.

128 patients underwent single or multiple GKRS procedures (Table 1).

**Table 1. Patient Demographics and AVM Characteristics**

Age	Median 37.5 years (range 6-73years)
Male (69 patients)	Median age 39 years (range 8-70 years)
Female (59 patients)	Median age 36 years (range 6-73 years)
<b>Symptoms</b>	<b>Number of Patients</b>
Intracranial Hemorrhage	18
Headache	83
Seizure	25
Vertigo	16
Nausea	7
Vomiting	7
Ataxia	6
Hemiparesis	13
Hemiplegia	2
Neurologic deficits	28
Neck pain	1
Insomnia	1
Syncope	6
Clonus	3
Excessive sweating	1
Slowed perception	2
Forgetfulness	6

# AVM Characteristics

- Spetzler-Martin grading system is used as a grading measure (Table 2).
- 113 patients underwent a single GKRS procedure.
- 13 patients underwent two GKRS procedures.
- 2 patients underwent three GKRS procedures.
- 12 out of 13 patients underwent volume-staged GKRS procedures.



**Table 3. Operational Parameters**

	<b>Number of Patients</b>
Single SRS procedure	113
Two SRS procedure	13
Three SRS procedure	2
<b>Single GKRS procedure</b>	<b>Median (range)</b>
AVM Volume	2.9 cc (0.05-14 cc)
Marginal dose	20 Gy (14Gy-25 Gy)
Isodose	50% (40%-65%)
<b>Two GKRS procedure</b>	
AVM Volume	17.9 cc (0.009-49.4 cc)
Marginal dose	17 Gy (15Gy-22 Gy)
Isodose	50% (40%-50%)
<b>Three GKRS procedure</b>	
AVM volume	42.82 and 18.80 cc
Marginal dose	15 and 18 Gy
Isodose	50%

AVM; Arteriovenous Malformation, SRS; Stereotactic Radiosurgery



# Patient Outcomes

55 patients (27 male, 28 female) achieved complete AVM obliteration, with a median obliteration time of **45 months (95% CI: 39-60)**.

Median AVM volume: **1.47 cc (range 0.009-21.8 cc)**

median dose: **21 Gy (range 14-25 Gy)**

Obliteration rates: 33%, 55%, and 68% at 3, 4, and 5 years respectively.

Factors influencing obliteration: AVM volume (**p = 0.026**), marginal dose (**p = 0.084**).

3 patients experienced intracranial hemorrhage (ICH), resulting in fatality for 1.

5 patients presented with new-onset seizures. Adverse radiation effects (ARE) were seen in 29 patients, with edema being the most common (Table 4).



**Table 4. Patients with Adverse Radiation Effects**

<b>Adverse Radiation Effect</b>	<b>Number of Patient</b>
Edema	19
Edema-related seizures	4
Headache	18
Radiation Necrosis	3
Cyst formation	2
<b>Neurologic deficits</b>	<b>14</b>
ataxia	1
Loss of sensation on the rightside of the body	2
Loss of sensation on the leftside of the body	1
Muscle Contractions	1
Loss of strenght in both arms	1
Loss of sensation around head	1
Slowing of speech and movements	1
Loss of sensation on the left upper extremity	1
Loss of sensation on the left hand	1
Facial dysesthesia	1
amnesia	1
Paresis in the extremities	2

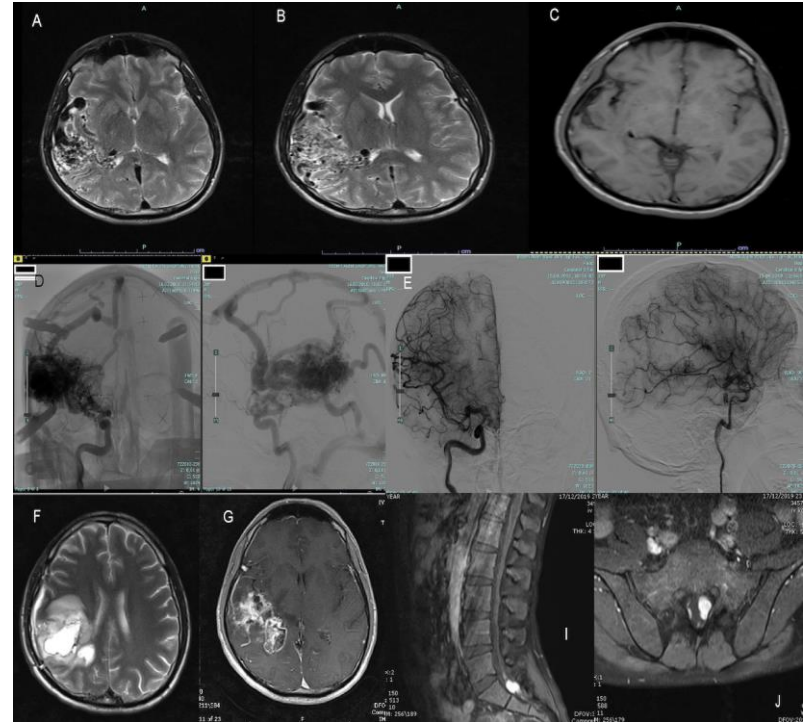
# Patient Outcomes

Higher ARE rates were observed in patients with Spetzler-Martin grades  $>3$  ( $p = 0.044$ ).

Favorable outcomes were achieved by 50 patients; 78 had unfavorable outcomes.

Lower AVM volume is associated with favorable outcomes ( $p = 0.018$ ), with marginal dose approaching significance ( $p = 0.086$ ).

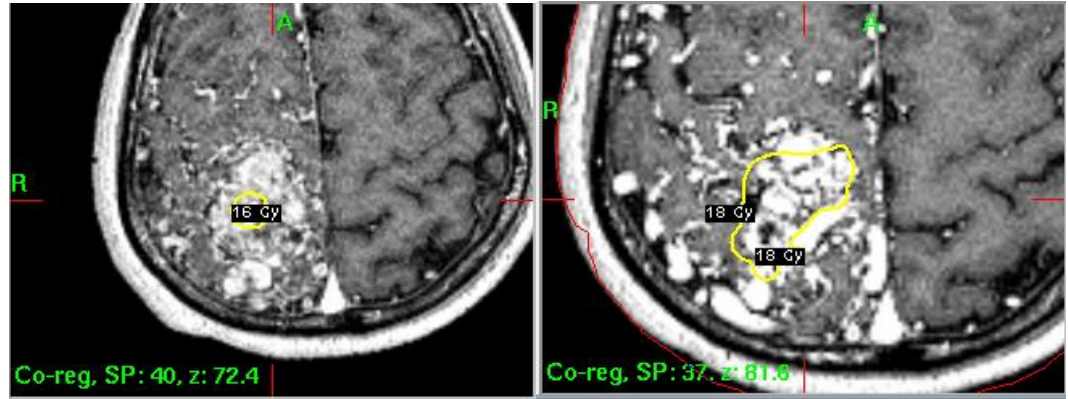
Notable cases: GBM diagnosis (1 patient), aneurysm development (1 patient), hydrocephalus (1 patient), stroke (1 patient).



# Future Directions and Overview of the literature

Multiple treatment modalities? Prior Embolization?

Volume vs Dose-staging?



# Conclusion and Key Takeaways

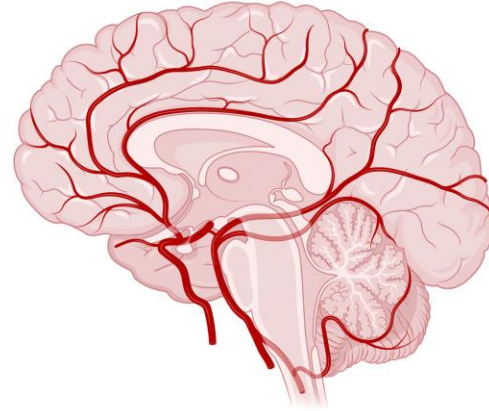
Treatment efficacy

Factors affecting outcome

Complications

Patient outcomes

Longterm follow-up



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