Hypofractionated Gamma Knife radiosurgery

- Radiosurgery of benign intracranial lesions. Indications, results , and perspectives
- Upfront frameless hypofractionated gamma knife radiosurgery for large posterior Fossa metastases
- Hypofractionated radiosurgery (25 Gy/5 fractions) for optic nerve sheath meningiomas: results from an exploratory phase 2 prospective trial
- Post-operative hypofractionated stereotactic radiotherapy for brain metastases from lung and breast cancer in patients without prior WBRT: a retrospective dose escalation study
- Hypofractionated Versus Single-Session Radiosurgery to Preserve Hearing in Patients Affected by Sporadic Vestibular Schwannoma: The ACOUNEU Randomized Clinical Trial
- Pheochromocytomas and Paragangliomas-Current Management
- Functional Transformation of a Corticotroph Pituitary Neuroendocrine Tumor 128 Months Following Primary Excision ? A Case Report
- Stereotactic radiotherapy for spinal and non-spinal bone metastases: a patterns-of-care analysis in German-speaking countries as part of a project of the interdisciplinary Radiosurgery and Stereotactic Radiotherapy Working Group of the DEGRO/DGMP

Hypofractionated Gamma Knife Radiosurgery (HF-GKRS) refers to delivering radiation in multiple sessions, typically for larger or critically located intracranial lesions where single-fraction radiosurgery could pose risks to nearby structures.

Indications

- Large brain metastases (>3–4 cm)
- Brainstem or posterior fossa metastases
- Skull base tumors
- Acoustic neuromas/vestibular schwannomas
- Meningiomas near optic pathways or cranial nerves
- Recurrent tumors previously irradiated
- Arteriovenous malformations (in selected cases)

Fractionation Schedules

Typical regimens vary, depending on tumor size, location, and proximity to critical structures. Common examples:

- 3 fractions of 7–8 Gy
- 5 fractions of 5–6 Gy
- 3–5 fractions over consecutive or alternate days

Equipment

- Gamma Knife Icon™ (Elekta) — allows mask-based fixation and frameless hypofractionation with high precision.
- Cone-beam CT and infrared motion tracking for image-guided delivery.

Advantages

- Improved normal tissue sparing (especially in eloquent areas)
- Allows treatment of larger lesions
- Lower risk of radiation necrosis
- Higher cumulative dose to tumor volume with fractionated repair

Limitations

- Requires patient compliance over several days
- Longer total treatment time compared to single-session GKRS
- Still limited data compared to conventional stereotactic radiotherapy (SRT)

Comparison with Other Modalities

Modality	Fractionation	Fixation	Use Case
Single-fraction GKRS	1 session (15–24 Gy)	Rigid head frame	Small, well-defined lesions
HF-GKRS (frameless)	3–5 fractions	Thermoplastic mask	Large or critical-area tumors
Linac-based SRT	5–30 fractions	Mask	More conformal for irregular shapes

Conclusion

HF-GKRS offers a promising alternative for patients with large or eloquently located intracranial lesions, balancing tumor control with preservation of neurological function.

Hypofractionated Gamma Knife radiosurgery is a specialized form of radiation therapy that delivers a high dose of radiation to a precise target in the brain in fewer sessions compared to traditional Gamma Knife radiosurgery.

During hypofractionated Gamma Knife radiosurgery, a team of healthcare professionals uses imaging techniques, such as MRI or CT scans, to precisely locate the tumor or abnormality in the brain and develop a treatment plan. The radiation is delivered to the target area using a specialized device called a Gamma Knife, which uses multiple beams of radiation to focus on the target with sub-millimeter precision.

Unlike traditional Gamma Knife radiosurgery, which delivers a high dose of radiation in a single session, hypofractionated Gamma Knife radiosurgery typically involves delivering the total radiation dose over two to five treatment sessions, spaced out over several days to weeks. This approach allows for a larger total dose of radiation to be delivered to the target area, while minimizing the risk of damage to surrounding healthy tissue.

Hypofractionated Gamma Knife radiosurgery is often used to treat small to medium-sized brain tumors, arteriovenous malformations, and other abnormalities in the brain that are difficult to reach with traditional surgery. The effectiveness of hypofractionated Gamma Knife radiosurgery depends on various factors, including the size and location of the target, the radiation dose, and the patient's overall health.

As with any medical procedure, there are potential risks and side effects associated with hypofractionated Gamma Knife radiosurgery. These may include fatigue, headaches, nausea, and skin irritation. More serious side effects such as brain swelling, radiation necrosis, and cognitive deficits are rare but can occur. Patients undergoing hypofractionated Gamma Knife radiosurgery should be closely monitored by their medical team to ensure proper management of any potential side effects.

In summary, hypofractionated Gamma Knife radiosurgery is a specialized form of radiation therapy that delivers a high dose of radiation to a precise target in the brain over two to five treatment sessions. It can be an effective treatment option for some patients with small to medium-sized brain tumors or other abnormalities in the brain. However, patients should be aware of the potential risks and side effects associated with this procedure and discuss them with their medical team before undergoing treatment.

Gamma Knife radiosurgery (GKRS) allows for the treatment of intracranial tumors with a high degree of dose conformality and precision. There are, however, certain situations wherein the dose conformality of GKRS is desired, but single-session treatment is contraindicated. In these situations, a traditional pin-based GKRS head frame cannot be used, because it precludes fractionated treatment.

Case series

Tripathi et al. prospectively evaluated 202 patients treated with frame-based hfGKRS over a 9-year period. GKRS was administered fractionated because of either a large volume (>14 cc) or an inability to spare neighboring organs at risk from permissible radiation in single-session GKRS. The inter-fraction interval was kept at 24 hours, and the dose calculation was performed with linear quadratic equations. Patients with more than 3 years of clinical and radiological follow-up were included in prospective analysis. At pre-decided follow-up criteria, treatment effects and side effects were documented on objective scales.

Results: A total of 169/202 patients met inclusion criteria. 41% patients received treatment in three fractions, whereas 59% received two-fraction GKRS. Two patients of giant cavernous sinus hemangiomas were treated with 5 Gy in the five-fraction regimen. In patients with more than 3 years of follow-up, the obliteration rate was 88% for complex arteriovenous malformations (AVMs) treated with hfGKRS because of eloquent locations, whereas it was 62% for Spetzler-Martin grade 4-5 AVMs. For non-AVM pathologies (meningiomas, schwannomas, pituitary neuroendocrine tumors, paragangliomas, hypothalamic hamartomas, etc.), the 5-year progression free survival was 95%. Tumor failure was noted in 0.05% patient population. Radiation necrosis developed in 8.1% patients, and radiation-induced brain edema developed in 12% patients. It was resistant to treatment in 4% patients. No patient developed radiation-induced malignancy. Hypo-fractionation did not provide any hearing improvement in giant vestibular schwannomas.

Conclusion: hfGKRS is a valuable standalone treatment option for candidates unsuitable for single-session GKRS. The dosing parameters need to be tailored as per the pathology and neighboring structures. It provides comparable results to single-session GKRS with an acceptable safety and complication profile [1)]

Hypofractionated Gamma Knife radiosurgery for brain metastases

Hypofractionated Gamma Knife radiosurgery for brain metastases

1)
Tripathi M, Kumar N, Sreenivasan SA, Ahuja CK, Jani P, Bhatta R, Kaur R, Mohindra S, Chauhan R. Hypo-fractionated Gamma Knife Radiosurgery for Intra-cranial Pathologies: A Single-Center Prospective Analysis of Feasibility, Safety, Efficacy, and Complication Profile. Neurol India. 2023 Mar-Apr;71(Supplement):S189-S197. doi: 10.4103/0028-3886.373638. PMID: 37026352.