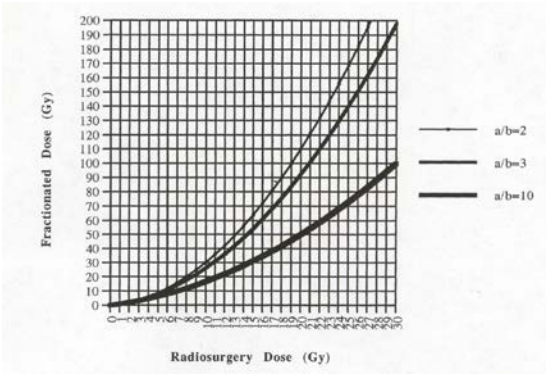
Stereotactic Radiosurgery

1. Clinical:
   - Normal brain tissue $TD_{5/5}$ = 45Gy whole, 50Gy for 2/3 and 60Gy for 1/3
   - Depends on if target is early or late responding tissue, and if target contains normal tissue or not:

Category	Target tissue	Target contains normal brain tissue	Examples
1	Late-responding tissue	Yes	AVM
2	Late-responding tissue	No	Meningioma, acoustic neuroma
3	Early-responding tissue	Yes	Low grade glioma
4	Early-responding tissue	No	Brain metastases, glioblastoma multiforme

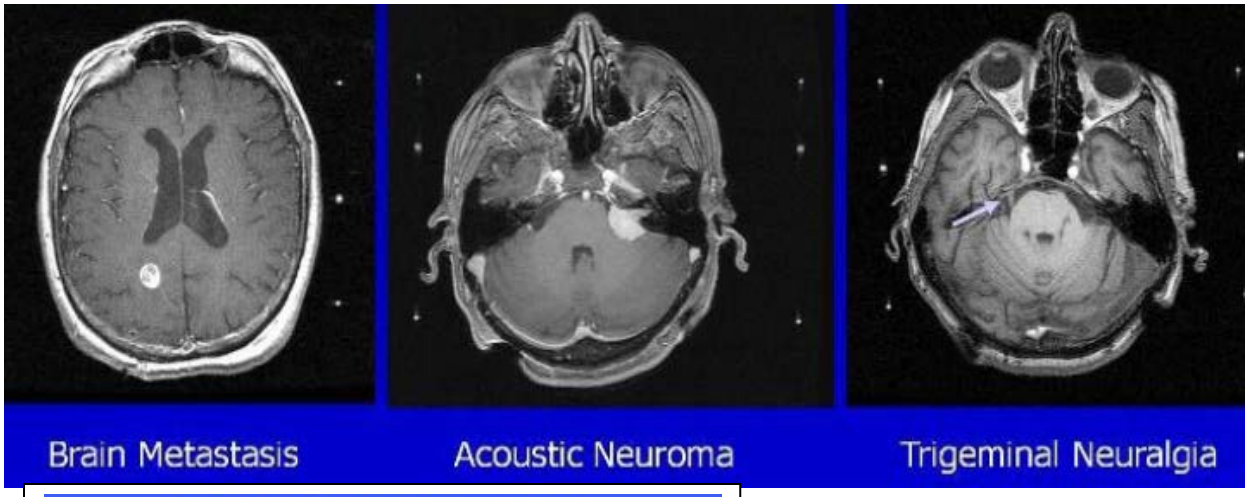
   - Vascular malformation AVM (Arteriovenous Malformation) :
     - Detected on T2 or time of flight MRI or angioCT
     - SRS to progressive thrombosis and subsequent luminal obliteration
     - Lesion < 3cm
     - Dose depends on volume and location of lesion [20-23Gy]
     - Volume of 12Gy (V_{12}) is important in (correlated with) complication rate
   - Trigeminal Neuralgia (TN) :
     - SRS targets the proximal trigeminal root
     - MRI for targeting
     - Max dose 70-90Gy
     - IU technique: 4mm collimator, 40Gy to 50% IDL
       With brainstem surface dose not exceeding 20 Gy
   - Benign tumors
     - Meningiomas
       - Ideal for SRS (category 2)
       - The typical prescribed dose is 12-18 Gy, depending on the size and the location of the tumor
     - Acoustic neuroma
       - They are Schwann cell derived tumors arising from the vestibular portion of the eighth cranial nerve
       - At IU, the typical prescribed dose to the tumor is 12-13 Gy, depending on the size of the tumor
     - Pituitary adenoma
       - Histological benign, but neurological and physiological consequences can be devastating
       - Typically, 25-30 Gy @ 50% IDL line for secretory tumors, as allowed by the constraints of the optic pathway dose. If the latter is exceeded, the prescribed dose should be scaled down
       - For non-secretory tumors, the goal is to prescribe 15-20 Gy @ 50% IDL, as allowed by the constraints of the optic pathway dose
       - Dose limiting normal tissue: optical nerve (<8Gy), optical chiasm <10Gy
       - Beam blocking plug patterns are often used to distort the peripheral isodose curves away from the optic apparatus

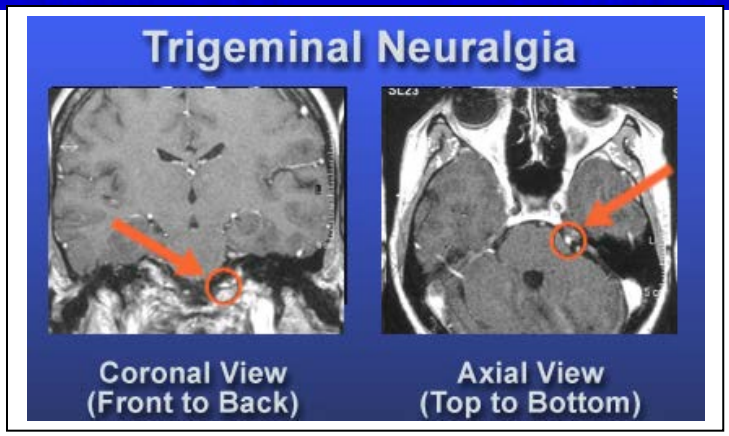


   - Malignant tumors (malignant glioma)
     - Tumors less than 3cm
     - Those not associated with a life-threatening mass effect

- 4 or less tumors simultaneously presenting in the brain with or without whole brain irradiation (to check)
- It is reasonable to follow RTOG guidelines (≤ 2 cm, 24 Gy; 2.1~3 cm, 18 Gy; 3.1~4 cm, 15 Gy); location is also a consideration

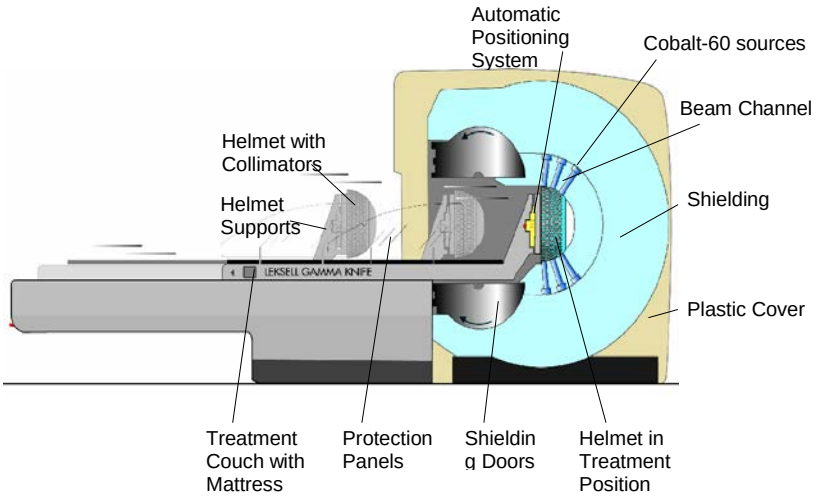
- Functional disorders





Normally, the minimal tumor size to treat is about 4mm which is limited by the technical and radio-physical tolerance.
The maximum tumor size is 4cm which is limited by radiation biology (how much normal tissue is involved).
The larger the tumor size, the lower the dose can be prescribed.

2. Gamma Knife



- Specifications;
  - 201 Co-60 sources (33Ci)
  - SSD = 40.3cm
  - Source lies in an arc of ±48° from the central beam and ±80° along the transverse axis of table. C.A.X of 201 beams intersect at focus of **±0.3mm (0.5mm?)**
  - 4, 8, 14 and 18mm diameter helmet with collimator
  - collimator with reduced SCD (source-collimator distance) => penumbra 1-2mm for collimators
  - Overall geometric uncertainty:
- Geometric accuracy:
  - The distance between the mechanically defined center to the radiological center -> gamma knife accuracy

    A very accurately machined film holder tool in which the mechanical iso can be identified by a sharp needle. The needle piece a film and compared with radiation iso. (<0.5mm when combined all 3 axis)
  - APS positioning accuracy: <0.2mm
  - Helmet positioning accuracy: <0.1mm

- Dosimetry:
  - Beam profiles (4 collimators): pre-stored in Gamma Plan.

    Can be measured by a single beam by using film placed 8cm depth in a phantom. Film should be calibrated using Co-60 teletherapy unit. [need to subtract background radiation]
  - PDD:

    IVS dominates and attenuation is small since SSD is short (40cm)
    PDD can be measured by diodes and
    all 4 collimators should have similar PDD.
  - Collimator output factor:

    Measured and normalized to 18mm helmet
    4mm has largest uncertainty
    Size of detector and alignment are major contributions to uncertainty
    Should be no greater than 1x1x1mm
  - Dose rate calibration

    Calibrated in a sphere phantom with 8cm radium (16cm diameter)
    Using 18mm collimator and all 201 sources

Monthly calibration should be within 2% (3% per NRC) with the decay corrected dose rate in TPS

- QA (10Part35.645):
  - Daily:
    Dry run
    APS check
    Mechanical (couch and hoist, haudritic backup)
    Safety (alarm, rad monitor, emerg stop, TX pause, door intl., intercom, survey meter)
    Microswitch test, Trunion centricity
    Timer termination
  - Monthly
    Dose rate
    Dose rate linearity (dose rate in 1min, 2min to 10min)
    Constancy (repeated readings)
    Time error
    Power loss
  - Annual:
    Beam profiles
    Output factor verification
    Dose rate
    Geometric accuracy

3. Linac based SRS
   - Cone (5mm-30mm, 12 conical collimators) or MLC based
   - Head ring for SRS (~0.5mm accuracy) ; bite tray with optical fiducial arrays for frameless SRT (about 0.5-1mm accuracy)
   - OGP (optical guidance position): accuracy of 0.3mm and 0.3 degree
   - For MLC based: isotropic conformal beams, or dynamic conformal arcing or IMRS
   - QA in three steps
     - Verify optical camera calibration (alignment between optical tracking center with mechanical ISO) (<`1mm)
     - Verify radiation isocenter for cone or MLC by Winston-Lutz test (alignment between radiation isocenter and mechanical ISO) (<0.5mm)
     - Three systems ISO (optical, mechanical and radiation) alignment established