The Role of the Medical Physicist in Gamma Knife®

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Gamma Knife
Gamma Knife®

Teletherapy device for the delivery of stereotactic irradiation to areas of the brain

The concept was originally developed by Lars Leksell, a Swedish neurosurgeon
Gamma Knife®

- First patient was treated in 1967
- University of Pittsburgh Medical Center installed the first unit in the US in 1987
- GRMC installed the B model in 2000
Gamma Knife®

- Perfexion™ was installed at GRMC in 2011
- 192 Cobalt-60 sources
- ~222 TBq/6000 Ci
- > 3 Gy/min at the focal point
- System accuracy of < 0.5 mm
Gamma Knife®

- Unit weighs ~20,000 kg
- Floor must withstand a total of ~35,000 kg
- Loader and cask
Treatment Indications

- ~120 units in the US
- ~300 units worldwide
- >700,000 patients have been treated through 2011
- Increasing by ~60,000 patients annually

Diagram showing:
- 45% Malignant
- 35% Benign
- 12% Vascular
- 8% Functional
Treatment Indications

Malignant Tumors
- Brain metastases – 15 to 24 Gy
- Glioblastoma multiforme – 15 to 18 Gy

Benign Tumors
- Vestibular schwannomas – 12 Gy
- Meningiomas – 15 to 16 Gy
- Pituitary Adenomas
  - Non-secretting – 16 to 18 Gy
  - Secreting – 20 to 24 Gy
- Craniopharyngiomas – 15 to 16 Gy
Treatment Indications

Vascular Disorders
- Arteriovenous Malformations – 18 to 24 Gy

Functional Disorders
- Trigeminal Neuralgia – 80 Gy
- Parkinson’s Disease or Essential Tremor – 140 to 150 Gy
- OCD – 140 to 150 Gy
Gamma Knife® Treatment

- Morphine and Versed
- Local anesthetic injected at pin sites
- Stereotactic frame is applied
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Daily QA
- General functionality
- Audio-visual communications
- Emergency Stop and Pause
- Warning lights
- Secondary radiation monitor
- Focus precision check
- Interlocks
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- Ensure frame adapter attaches to frame
Frame cap fits
Frame cap doesn’t fit – take post/screw measurements
GammaPlan® may require measurements anyway
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- Bubble measurements – GammaPlan® uses an algorithm that “maps” out a skin surface
  - Clearance calculations
  - Dose calculations
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- MRI localizer
- Obtain MRI
- Transfer images to GammaPlan®
- Localizers for CT and Angiogram
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Definition process
- Fiducial markers identify stereotactic space
- Check for distortion

Verify correct orientation of image set
Gamma Knife® Treatment
Gamma Knife® Treatment

- Place “shots” to cover target
- 192 sources are divided into 8 sectors
  - 16 mm
  - 8 mm
  - 4 mm
  - blocked
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Gamma Knife® Treatment
Gamma Knife® Treatment
Gamma Knife® Treatment

- Approve plan and export it to the treatment console

- Pre-treatment checks
  - Clearance, coordinates are within limits and independent measurements of fiducials
  - Calibration/treatment dose rate is correct
  - Hand calculation
  - Plan is correctly transferred to treatment console
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- Mount frame adapter
- Secure anterior lever with locking screw
- Adjust couch for patient comfort
- Verify patient ID
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- Clearance run
- Clearance check tool simulates the collimator cap
- Drive the table to simulated treatment coordinates
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- Treatment delivered remotely
- AU and AMP must be present
- Treatment cycles through the planned shots
- Sectors move to correct collimation once treatment coordinates have been reach
Emergency Procedures

- Treatment Pause – initiates treatment stop sequence
- Emergency Stop – halts all movement, upon release the treatment stop sequence is initiated
- Sources will immediately move to beam OFF position
Emergency Procedures

- Manual pull-out of the couch
  - Release table clutch
  - Manually pull couch out
  - Undock patient and escort out of the room

- May have to undock patient inside the machine if the table does not release
Emergency Procedures

- If shielding doors do not close, they may be manually cranked closed.
- If sectors fail to return to HOME position, they may be manually pulled back.
Physics Testing

- Daily QA
- Monthly QA
  - Dose rate
  - Timer Error
  - Timer Accuracy
  - Timer Constancy
  - Timer Linearity
  - Loss of power
  - UPS/batteries
  - Clearance check
Physics Testing

Annual Testing
- Full calibration
- TLDs from RPC
- Radiochromic films
  - Radiation and mechanical isocenter coincidence
  - Beam profiles
- Anthropomorphic phantom
  - Irradiated just like a patient
  - Evaluates entire treatment process
Case Studies
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Gamma Knife® Extend™