Leksell Gamma Knife Icon
A New User’s Perspective

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Disclosures

• None
Outline

• Icon Overview
• Mayo Clinic Experience
• Frame-Based System
• Mask-Based System
• Linac Single Isocenter Technique
Icon Overview

• Essentially the same as the Perfexion with the addition of:
  • Mask immobilization system
  • CBCT
  • High Definition Motion Management (HDMM) system

• Framed, frameless, and fractionated treatments

• Allows for pre-treatment and during treatment verification of patient positioning
Icon Overview

- Commercially available in 2016
- 192 Co-60 sources
- ~6600 Ci at installation
  - ~35 Ci per source
- 4, 8, and 16 mm collimators
  - Sources divided into 8 sectors that can be collimated/blocked independently (24 sources/sector)
  - Sources also divided into 5 rings
- Initial output ~3.5 Gy/min for the 16 mm collimator
Mayo Clinic Florida Experience

• First treatment in January 2018
  • ~100 patients total
  • ~50% mask based
    • ~1/3 of mask patients are fractionated
  • Mostly brain mets

• Treatment durations range from ~15 minutes to hours

• Number of mets range from 1 to 30+
  • Vast majority of cases have 1-10 mets
SRS vs Whole Brain

- Recent trend towards treating more mets and less whole brain

- Randomized data only exists for a small number of brain mets (1-3)
  - Studies looking into more mets are underway (5-15)

- SRS is believed to be associated with less cognitive side effects than whole brain

- Other factors such as tumor volume, performance status, histology, etc. are also important

- Physician dependent
Frame-Based Workflow @ MCF

• Day before treatment
  • MRI (without frame)
  • Preplan

• Morning of treatment
  • Frame placement
  • CT sim with fiducial box to establish stereotactic space
  • Co-register CT sim to preplan MRI

• Treatment Delivery
  • CBCT
  • Co-register CBCT to CT sim to verify position/dose distribution
    • Can’t apply corrections
  • Deliver treatment
Framed Treatment Delivery

Dashed = Planned, Solid = Delivered
Framed Treatment Delivery

Dashed = Planned, Solid = Delivered
Framed Treatment Delivery

Planned:

\[ 0.595 \text{ cm}^3 \ (99.5\%) \geq 20.0 \text{ Gy} \]

Actual:

\[ 0.469 \text{ cm}^3 \ (78.5\%) \geq 20.0 \text{ Gy} \]

Dashed = Planned, Solid = Delivered
Framed Treatment Delivery
Do Frames Move?

- For **properly mounted** frames, 2% of patients had frame shifts > 1 mm \[1\]
- CBCT on the Icon allows these shifts and shifts due to improper frame placement to be detected and corrected prior to treatment
Mask-Based System

- CBCT must be used for stereotactic space
- CBCT field of view can be limiting for extreme target locations
- CBCT used to correct shot locations based on treatment position
- High Definition Motion Management (HDMM) system used to verify patient position throughout treatment
CBCT Correction

• Delivery of plan is automatically corrected according to actual patient position (from CBCT)

• Correction is done so the delivery preserves the planned position of each individual isocenter (shot) in the patient anatomy \[2\]

*Figure 2. Original plan. The target volume with individual shots outlined.*

*Figure 3. Rotation 5° about the z-axis.*
CBCT Correction Verification

Rotation [degrees]

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Translation [mm]

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HDMM System

- Looks at patient position (via nose marker) relative to reference markers in the mask adapter
- If movement exceeds a user defined threshold, collimators move to blocked position
  - Treatment is paused if above threshold for 30 seconds or exceeds threshold more than 5 times within a single shot
HDMM System

- System can accurately measure movements of 0.1 mm $^{[3]}$
- Motion of nose marker using HDMM system has been found to be greater than or equal to target motion measured via CBCT $^{[4]}$
Mask-Based Workflow @ MCF

• Day Before Treatment
  • MRI
  • Create mask
  • CBCT (stereotactic reference)
  • CT Sim
  • Planning

• Treatment Delivery
  • CBCT
  • Co-register to previous CBCT
  • Verify corrected dose distribution
  • Deliver treatment
Mask Treatment Delivery

<table>
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<tr>
<th>Patient position</th>
<th>X</th>
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<tbody>
<tr>
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<td>Translation [mm]</td>
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Correction applied: Yes

Dotted Line: Planned
Solid Line: Current (CBCT)
Mask Treatment Delivery
Gamma Knife Icon Summary

- System allows efficient and accurate treatment delivery
- Addition of mask provides a lot of flexibility
- Addition of CBCT is necessary for mask-based treatments
  - Provides a lot of value for frame patients as well
- HDMM system provides an acceptable way to track intra-fraction motion
  - May cause excessive treatment stoppages due to the nose marker being used as a surrogate
- Gamma Knife vs. Linac?
Linac Single Isocenter Technique

• Treat multiple mets off-axis with a single isocenter
  • Isocenter often placed in the geometric center of the targets
  • Intensity-modulated or dynamic conformal arc
  • User-defined or template-based planning

• Plan quality is comparable to multiple isocenter technique and Gamma Knife
  • Margins? Prescription Isodose Line?

• Treatment time can be significantly shorter than other techniques

• QA time can be significantly longer than other techniques
Mayo Clinic Florida Experience

• 2-6 targets treated per isocenter
• Keep all targets within the HDMLCs
• Treatment time ~25 minutes
• Intra-fraction imaging used when possible
• Primarily used for patients who cannot tolerate longer treatment times
Single Isocenter SRS QA

- Radiochromic film most commonly used
  - Often requires multiple measurements due to off-axis target locations
  - Choose measurement planes to minimize number of film measurements needed

- Passing Criteria: >95% @ 2%/2mm

- Recently began doing a secondary TPS calculation as well for comparison
Questions?
References


