Gamma Knife and Axesse Radiosurgery

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Origin of Radiosurgery
The first step towards the Gamma Knife®

Radiosurgery definition

“The delivery of a single, high dose of irradiation to a small and critically located intracranial volume through the intact skull”

Lars Leksell, 1951

Initial work with single radiation source using orthovoltage X-ray (pictured) then proton beam
Gamma Knife® radiosurgery - principles

Gamma Knife: Multiple source design:

- Protective shielding
- Collimator channels
- Leksell® Coordinate Frame
- Isocenter/Target in the brain
- Patient positioning system
- Radiation sources
The evolution of technology 1987-2011

Overview

Perfexion

C: robotic

4C
The steps towards **Gamma Knife® surgery**

Established the field of SRS more than 30 years ago

Technology continues to evolve through innovation
- Clinical applications
- Workflow and throughput

Experiencing a stronger market position now than ever before

As a result, Leksell Gamma Knife is still regarded the Gold Standard in Intracranial Radiosurgery
Perfexion Collimator Design

1. Four different collimator stations: 0 (blocked), 4mm, 8mm, 16mm diameter

2. Arranged in 8 sectors

3. Mixtures of different collimator sizes allows for creating ellipsoid shapes and makes it easier to shape plans with 70-90% isodoses

4. Move to 0 (blocked) setting between isocenter positions

5. Easy blocking of beams through sensitive structures
Perfexion Unit: Collimator Design

• Larger aperture: patient repositioning and frame shifting rarely required
• Entire bed moves for patient positioning, not just the head: more comfortable
• Beam channels close in between positions and then bed moves directly from one isocenter to the next.

Source: AANS/CNS Treatment Guidelines for brain mets (2009); “Neurocognition in patients with brain metastases treated with radiosurgery or radiosurgery plus whole-brain irradiation: a randomized controlled trial”, Eric J Chang et.al. (2009)

Close Up Drawing Of One Perfexion collimator sector with 8-mm beams
Improvements in Perfexion Unit

- Larger aperture: patient repositioning and frame shifting rarely required
- Entire bed moves for patient positioning, not just the head: more comfortable
- Beam channels close between isocenter positions and then bed moves directly from one isocenter to the next (improved efficiency)

Source: AANS/CNS Treatment Guidelines for brain mets (2009); “Neurocognition in patients with brain metastases treated with radiosurgery or radiosurgery plus whole-brain irradiation: a randomized controlled trial”, Eric J Chang et.al. (2009)
Aims: We analyzed the efficiency of the Leksell Gamma Knife Perfexion (LGK PFX) in the treatment of multiple metastases and benign tumors. We also compared treatment planning conformity between LGK PFX and LGK 4C for benign tumors.

Method: Over a 6-week interval, 37 patients (21 with multiple brain metastases and 16 with benign tumors) underwent radiosurgery using LGK PFX at the University of Pittsburgh. We created dose plans for all patients using Leksell Gamma Plan for LGK PFX and LGK 4C. The same doses were prescribed for both LGK PFX and LGK 4C.

Results: No significant difference was observed between LGK 4C and LGK PFX for total beam-on time. The median reduction in setup time on the LGK PFX was 53 min per patient (range 19–125 min) for multiple metastases. The median reduction in setup time on the LGK PFX for benign tumors was 16 min per patient (range 5–53 min). There was no significant difference in the dose conformality between LGK 4C and LGK PFX.

Conclusions: This study demonstrated that in addition to its enhanced cranial reach, LGK PFX provided a significant improvement in efficiency for patients with multiple brain metastases. For benign tumor radiosurgery, LGK PFX provided improvement in efficiency without a significant difference in conformality.
Radiosurgery is the ideal treatment for brain metastases

- Brain metastases moderately well circumscribed
- High control rates reported with minimal morbidity
  - Prolonged survivals are possible
  - Survival related to extracranial disease
  - Less toxicity (hair loss, nausea)
- Allows continuation of systemic therapy
- Its use does not preclude salvage XRT / WBRT
- Few side effects - neurocognitive issues not a concern
The Extend™ system opens up for new clinical possibilities

- **Fractionation**
  - Malignant tumors in the head and neck
  - Benign lesions not suited for traditional radiosurgery

- **Radiosurgery**
  - When the highest accuracy is not needed and a non-invasive fixation is preferred
# Accuracy

<table>
<thead>
<tr>
<th><strong>Type of accuracy</strong></th>
<th><strong>Definition</strong></th>
<th><strong>Leksell Gamma Knife®</strong></th>
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</thead>
<tbody>
<tr>
<td>Mechanical accuracy</td>
<td>The sum of all mechanical tolerances</td>
<td>&lt;0.3mm</td>
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<tr>
<td>Radiological accuracy</td>
<td>Accuracy of the system, incl. mechanical accuracy plus beam delivery accuracy</td>
<td>0.15mm average (Guaranteed to &lt;0.50mm)</td>
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<tr>
<td>Total clinical accuracy</td>
<td>Radiological accuracy plus imaging inaccuracies</td>
<td>0.48mm</td>
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1) The figure is based on 332 measurements over a period of two years on 189 installed systems.


Elekta guarantees the accuracy of Leksell Gamma Knife® for its entire lifetime* – no other radiosurgery system does the same.

* With a valid service agreement
LGK Perfexion extracranial doses in the order of 10-100 times lower than for other devices

The treatment procedure - done in one day

1. Frame fixation
2. Diagnostic imaging
3. Treatment planning

MR compatible frame: eliminates MR to CT fusion errors

4. Treatment
What is Axesse?

Elekta’s LINAC based Stereotactic Radiosurgery Platform for the total body – from head to toe.
Axesse™ in Elekta portfolio

- Elekta LGK Perfexion
- Elekta Axesse
- Elekta Synergy / Infinity
- Apex
- Synergy Platform
- Compact

- CRT Large field
- IMRT Large field
- H/N IMRT
- Prostate IMRT
- Lung Liver SBRT
- Spine SRS
- Brain SRS
- Brain Functional
Elekta Axesse™ Components

- Delivery System
- 2D, 3D and 4D kV image guidance
- Integrated Beam Shaping (mMLC)
- Versatile patient immobilization
- 6D robotic patient positioning
- Radiobiological treatment planning
- EMR centered workflow
Elekta Axesse™ – Core functionalities

- **Drum gantry**
  - Stable, reliable, no bearing to maintain
  - Matched kV & MV iso-centers + electronic compensation => Total accuracy ≈ 0.6 mm (radius)

- **Integrated μMLC**
  - 4 mm leaf width, 4 mm penumbra, full interdigitation
  - Superior patient clearance

- **Elekta VMAT dose delivery**
  - MLC, head rot, gantry rot and doserate continuously modulated

- **User values:**
  - Total clinical accuracy < 1.0 mm
  - Fast and seamless dose delivery
  - Multiple targets treated simultaneously
  - Freedom to use non-coplanar fields and arcs
  - No need for higher dose-rate
• **Integrity™** = **sixth generation** of digital control system:
  - Twenty years of experience built-in
  - One system controls all parameters
  - No analog electronics whatsoever
  - Totally integrated system
  - No internal interfaces, delays or lags
  - No tuning required
  - Simultaneous modulation of:
    - MLC
    - Gantry rotation
    - Head rotation
    - Dose-rate

• **Clinical user values:**
  - Safety, safety, safety...
  - Superior beam modulation capabilities
Best patient clearance on market means:

- Unrestricted beam access from all directions
- Freedom to apply advanced non-coplanar multiple arc VMAT
- Dose delivery can be optimized to patients physionomy rather than equipment geometry
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Elekta Axesse™ – Clinical Advantages

- Excellent, reliable cone beam images
- Accurate, reproducible, matching of cone-beam CT to planning-CT scans
- Smoothly integrated hexapod tabletop function