Gamma Knife (GSR)
stereotactic radiosurgery

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Gamma Knife (GSR) - stereotactic radiosurgery

- **Petti et al.: AAPM TG-178 Report on gamma stereotactic radiosurgery, Recommendations on the practice of calibration, dosimetry, and quality assurance for gamma stereotactic radiosurgery, 2021**
- **IAEA TRS – 398 Chap 5 , reference for $Co60$, 2000**
- **Quality Assurance Aspects and Requirements, Author:** Günther H. Hartmann Ph.D., **Publication:** Springer eBook, **Publisher:** Springer Nature, **Date:** Jan 1, 1995, *Copyright © 1995, Springer-Verlag Berlin Heidelberg*
- **Medical Physics Letter, 2008 American Association of Physics in Medicine, by R. Alonso, et. Al.**
- **Physics of Gamma Knife approach on convergent beams in stereotactic radiosurgery, 1990 Int. J. Radiation Oncology Biol. Phys. Vol 18, pp 941-949, Andrew Wu, et. Al.**

GSR (Gamma Knife Technology)

- Brief history of stereotactic radiosurgery
- Operational Concepts: mechanical, electrical, dosimetrical, and information technology
- Daily , monthly , tests required following a major repair of a GSR device
- Equipment used for GRS QA tests
- Dosimetry of small fields

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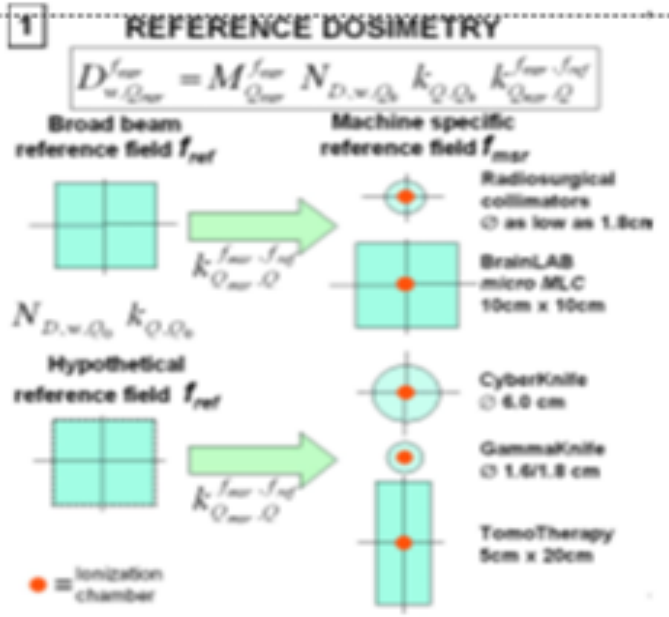
Brief history of stereotactic radiosurgery

- **1951 in Sweden, Lars Leksel, MD, applied protons in radiosurgery of brain**
- **Cyclotron is a high cost radiation device**
- **1968 Solution was $^{60}Co\ micro-spheres$**
- **Nowadays it is common 200 microspheres**



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Dosimetrical tests: includes phantom positioning movements of the couch, here you can check electrical systems , dosimetrical tests , IT system

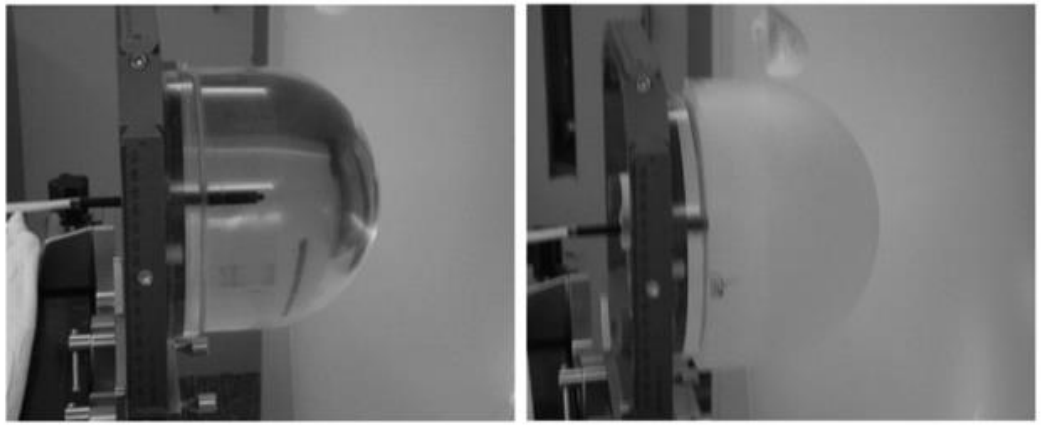

FIG. 2. Phantom and Leksell™ frame mounted on CT scanner couch (left) and with outer rind attached (right).

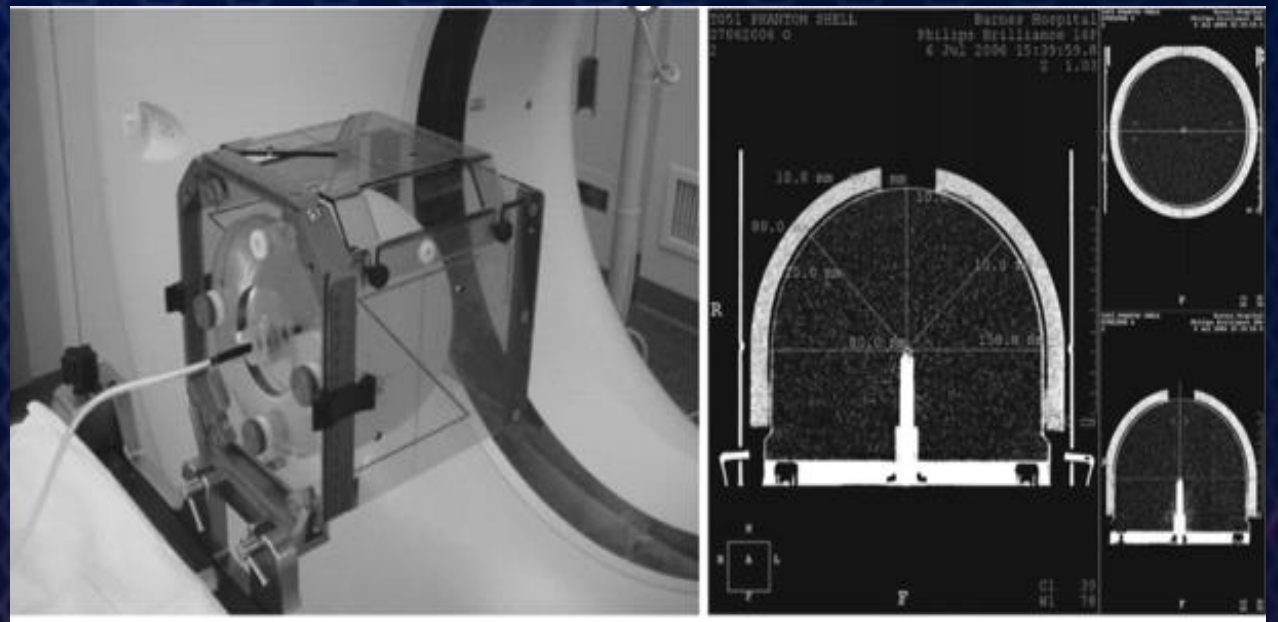

FIG. 3. Phantom with chamber and localizer ready for a stereotactic CT scan (left) and the resultant coronal view (right).

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Operational Concepts: mechanical, electrical, dosimetrical, and information technology

- **Mechanical includes pneumatic system to move the target according to coordinates**
- **Coordinates centralized : X=100 cm, Y=100 cm, Z= 100 cm.**
- **Include tables with equipment specifications**
- **Documentation of all tests**

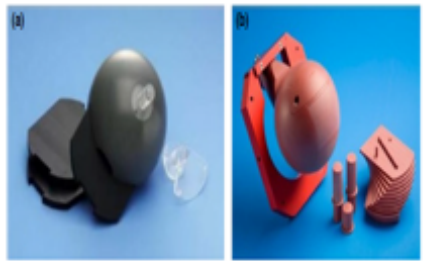


FIG. 4. (a) Elekta ABS and (b) Elekta Solid Water spherical phantoms (reprinted with permission from Elekta Instrument AB). The ABS phantom has a slot to accommodate different inserts (shown in figure) that hold an ionization chamber, cut film, or TLDs. The Solid Water phantom has plug-like inserts (shown in figure), which must be drilled to accommodate the ionization chamber. A single film or a stack of films can also be irradiated inside this phantom using the inserts shown. The ABS phantom attaches to the Perfexion/Icon PPS (i.e., the treatment couch) using the special phantom holder shown in Fig. 1, whereas the Solid Water phantom attaches to the PPS using the patient frame adapter. [Color figure can be viewed at wileyonlinelibrary.com]

Quality Assurance Program on Stereotactic Radiosurgery

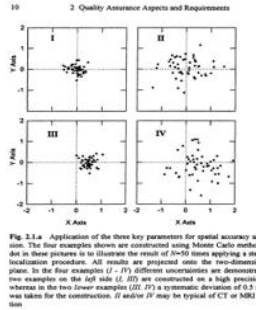
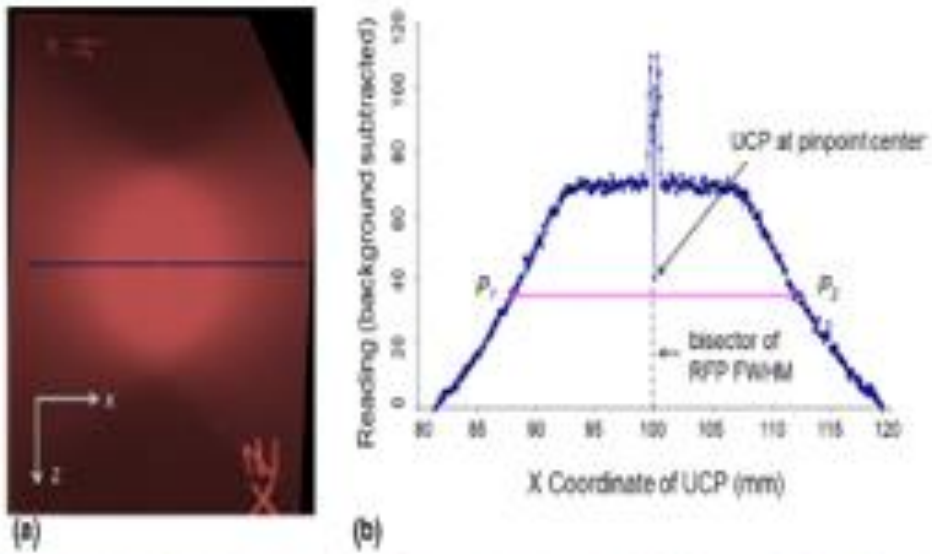


Fig. 2.1.a Application of the three key parameters for spatial accuracy and precision. The four examples shown are constructed using Monte Carlo methods. Each dot in these pictures is to illustrate the result of N=50 times applying a stereotactic localization procedure. All results are projected onto the two-dimensional x/y plane. In the four examples (I – IV) different uncertainties are demonstrated. The two examples on the *left* side (I, III) are constructed on a high precision basis, whereas in the two *lower* examples (III, IV) a systematic deviation of 0.5 mm in X was taken for the construction. *II* and/or *IV* may be typical of CT or MRI localization

FIG. 1. Illustration of the ionization chamber orientation that was used for the Elekta Monte Carlo simulations to determine $k_{Q_{msr},Q_0}^{f_{msr},f_0}$ factors in the Elekta ABS phantoms. The red phantom holder, which attaches to the patient couch and holds the ABS phantom, is also included in the Monte Carlo simulations. (Reprinted with permission from Elekta Instrument AB.) [Color figure can be viewed at wileyonlinelibrary.com]

Dosimetrical Tests



1. (a) An example of a pinpoint film irradiated with the 16 mm collimator in x-z plane with EBT radiochromic film. The red channel has been extracted, e intensity levels have been inverted. (b) A profile along the horizontal line through the pinpoint shown in part (a). The points P_1 and P_2 in part (b) are the ints of a line roughly corresponding to the FWHM. This line does not need be exactly at half the maximum intensity level. [Color figure can be viewed at nlinelibrary.com]

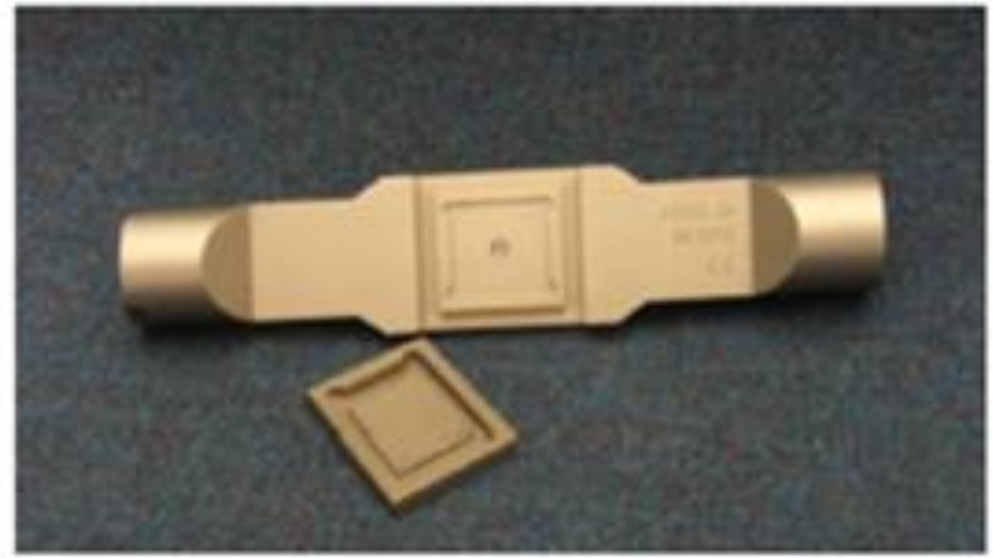


Fig. 5. Film holder used to confirm the coincidence between the RFP and the UCP for Leksell GSR units prior to the Leksell Gamma Knife Perfexion. (Reprinted with permission from Elekta Instrument AB.). [Color figure can be viewed at wileyonlinelibrary.com]

Acceptance tests list for the equipment

- **Manufacturer manual**
- **Acceptance tests**
- **Daily checks**
- **Weekly checks**
- **Monthly**
- **Annual**

Software data for backup

- SW data and backup
- Backup procedure : daily, weekly
- Check list for data backup
- Who is the staff involved ?

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Treatment protocol interdisciplinary staff: should be very well known for all members.

FIG. 12. Leksell headframe on phantom (left) and with MR indicator box (right). The fiducial channels, which are filled with copper sulfate, are outlined by dashed lines. The origin of the Leksell coordinate system is at the superior-right-posterior corner of the fiducial box, and the positive directions of the x, y, and z axes are as shown in the figure. [Color figure can be viewed at wileyonlinelibrary.com]

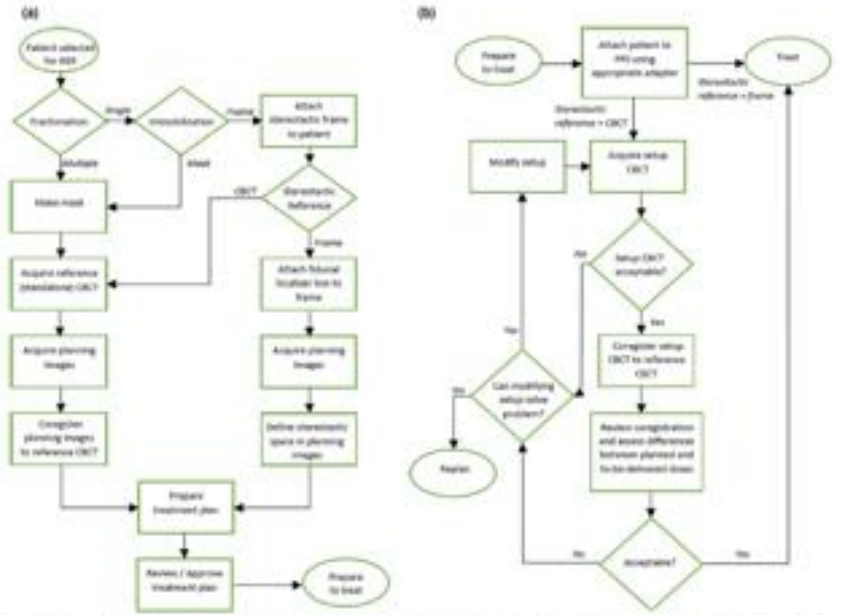

FIG. 13. (a) Flowchart describing steps leading up to patient treatment with Elekta GSK devices. (b) Flowchart illustrating treatment setup steps for Leksell Gamma Knife devices. [Color figure can be viewed at wileyonlinelibrary.com]

Dosimetry : Tests for beam accuracy

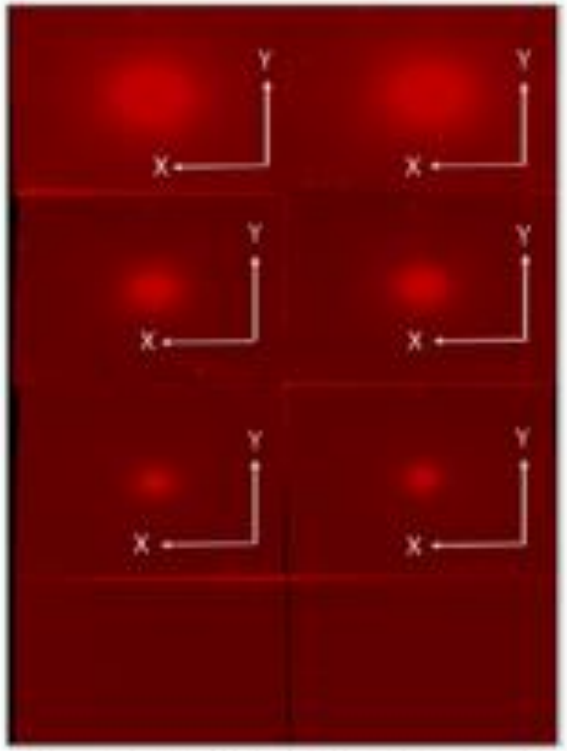

FIG. B2. An example of films irradiated to 4 Gy in the spherical dosimetry phantom on a Leksell Gamma Knife Perfexion unit in order to verify the ROPs used in the TPS. All eight films have been scanned together and stored as a single TIFF file. The ImageJ program has been used to extract the red channel and invert the intensity levels. [Color figure can be viewed at wileyonlinelibrary.com]

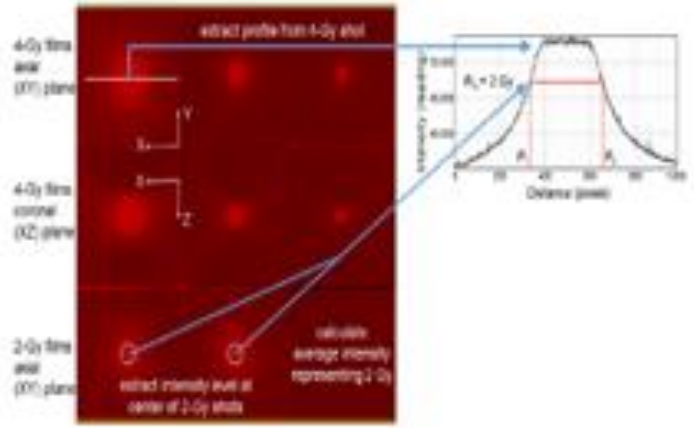

FIG. B4. Example of scanned profile films for a Leksell Gamma Knife Perfexion system. The top row shows films irradiated in the axial (x–y) plane with the 16-, 8-, and 4-mm collimators to a maximum dose of 4 Gy. The middle row shows films irradiated in the coronal (x–z) plane for the same three collimators, and the bottom row shows two calibration films irradiated to a maximum dose of 2 Gy with the 16-mm collimator in the axial plane. The insert on the right side of this figure illustrates how to determine the FWHM from a profile extracted from one of the 4 Gy films. The average reading, R_2, corresponding to 2 Gy plus background is illustrated by the horizontal red line on the extracted profile. This 2-Gy value is determined from the calibration films in the final row of the scanned film set by averaging the mean intensities at the center of each of the 2-Gy films. Here, FWHM = $s \times (P_2 - P_1)$, where s is the length of a scanned pixel in mm (determined from the scanning resolution). In this example, $P_2 = 547$, $P_1 = 204$, and $s = 0.0635$ mm/pixel for 400 dpi. Therefore, FWHM = 0.0635 mm/pixel × 343 pixel = 21.78 mm, which compares favorably with the expected FWHM along the x axis for the Leksell Gamma Knife Perfexion 16-mm collimator (Table B1). [Color figure can be viewed at wileyonlinelibrary.com]

Protocols in Clinics

- List of all equipment
- Mechanical
- Electrical
- Dosimetry
- Software and hardware

- Homemade developed software should include tests of cases known by the clinical engineering staff
- Protocols
- 3d source software should be accompanied by tests for acceptance and maintenance

Protocol in Clinics

- Review and updating of the clinics protocol
- Staff should be constantly involved
- At least once/month must be a meeting
- All dosimetry procedures must be periodically checked
- Clinical engineering should be able to modify procedures

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Thank you!

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