From U to Esprit
-A Physicist Tribute To Dr Steven Goetsch

LIJUN MA, PhD, FAAPM

2023 SC Winter Meeting
Los Angeles Universal Sheraton
First World Championship Game AFL vs NFL

Leksell Gamma Knife U (1967 1st Prototype)

Leksell Gamma Knife Esprit (2023 1st US Model)
Steve hands down on U (1999)

Thumb up an Icon (2020)
Raising Up The Young (2006)

Lifting Up The Old (1998)
work, indeed!

Linear accelerators do well with larger spherical lesions, such as brain mets and gliomas. A single isocenter with a large collimator (e.g., 20 to 40 mm diameter) may be nearly ideal for such a case. Arteriovenous malformations may often be well covered by 1 to 3 isocenters, particularly in non-eloquent brain areas. At this writing, linac radiosurgery systems alone have been used for fractionated stereotactic radiotherapy (SRT) (Dunbar 1994). A linac on a robotic arm developed at Stanford University Medical Center by Adler et al. is pioneering the introduction of frameless radiosurgery and has already treated several brain met patients (Cox 1993, Adler 1993). Hamilton and others at the University of Arizona have begun extracranial radiosurgery using a linear accelerator to stereotactically treat inoperable spinal tumors (Hamilton 1995).

3. GAMMA KNIFE TREATMENTS

A. Typical Timeline

Since the Gamma Knife is a single-purpose device, it has an enormous advantage in efficiency over many linac-based radiosurgery systems, which can often be used only “after hours,” that is, after all conventional radiation therapy patients have had their daily treatments. Thus, linac-based systems (exclusive of dedicated radiosurgery systems) must be reassembled and the functionality and accuracy of pointing of the system must be checked each day. This can add 1 to 3 hours to treatment time, especially if adjustments are necessary. The Gamma Knife, by contrast, requires only a brief daily inspection and function test prior to use.

A typical Gamma Knife timeline would be as follows: the patient arrives at the Gamma Knife Center at 6:00 a.m. Initial blood pressure, respiration, O₂ saturation and other vital signs are taken by the nurse. An intravenous line is placed for use throughout the procedure for radiographic contrast and administration of drugs. A “cocktail” of anesthetic and relaxing agents are administered and topical anesthetic may be placed at temporal and occipital lobe locations of the four pin sites. At 7:00 a.m., the neurosurgeon and radiation oncologist arrive and begin to study the frame placement, while the physicist makes daily performance checks on the Gamma Knife and the computer and may check the functioning of the local PACS system. By 7:45 a.m. the frame has been placed and the patient is transported by wheelchair or gurney, fully awake and alert, to the radiology department, where a computerized tomography or magnetic resonance imaging study is performed, typically with IV contrast. By 8:30 the patient is in the nursing unit relaxing, while the radiographic scans are being transported to the planning computer. By 8:45 a.m., the neurosurgeon, radiation oncologist and physicist are at work outlining the tumor and planning the treatment. For a small tumor in a non-critical area, the planning process may take as little as 15 minutes. For a more
Optimized intensity-modulated arc therapy for prostate cancer treatment

Lijun Ma Ph.D., Cedric X. Yu D.Sc., Matthew Earl Ph.D., Tim Holmes Ph.D., Mehrdad Sarfaraz Ph.D., X. Allen Li Ph.D., David Shepard Ph.D., Pradip Amin M.D., Steven DiBiase M.D., Mohan Suntharalingam M.D., Carl Mansfield M.D., D.Sc. ... See fewer authors

First published: 26 October 2001 | https://doi.org/10.1002/ijc.1039 | Citations: 30

† The contents of this article do not necessarily reflect the position or the policy of the United States Department of Defense or the United States Army, and no official endorsement should be inferred.
Ranged Modulated Helical Electron Beams

**Abstract**

A device for generating helical electron beams that can be used for radiation therapy is disclosed. The device contains a tertiary collimating cone that can be attached to a gantry of a linear accelerator or placed directly below the gantry. The tertiary collimating cone has a dynamic energy compensator and a magnetic electron collimator to modify the energy of electrons and to generate a helical trajectory. A multileaf collimator may be present within the tertiary collimating cone. A computer coordinates the movements of various components. The helical electron beam produced by this device can be targeted to tumors better and safer and reduce the amount of radiation hitting normal tissue than current devices.

34 Claims, 6 Drawing Sheets
Finally -
Gamma Knife Radiosurgery @
“The Best Place on Earth”

Dr. Lunsford pioneered US Leksell Gamma Knife radiosurgery, which transformed its business and world-wide clinical applications
Radiation measurement physics

A round-robin gamma stereotactic radiosurgery dosimetry interinstitution comparison of calibration protocols


First published: 30 October 2015 | https://doi.org/10.1118/1.4934376 | Citations: 10

Read the full text ➤
Recommendations on the practice of calibration, dosimetry, and quality assurance for gamma stereotactic radiosurgery: Report of AAPM Task Group 178

Paula L. Petti, Mark J. Rivard, Paola E. Alvarez, Greg Bednarz, J. Daniel Bourland, Larry A. DeWerd, Robert E. Drzymala, Jonas Johansson, Keith Kunugi ... See all authors

First published: 10 March 2021 | https://doi.org/10.1002/mp.14831 | Citations: 8

Abstract

The American Association of Physicists in Medicine (AAPM) formed Task Group 178 (TG-178) to perform the following tasks: review in-phantom and in-air calibration protocols for gamma stereotactic radiosurgery (GSR), suggest a dose rate calibration protocol that can be successfully utilized with all gamma stereotactic radiosurgery (GSR)
1967: 1st Gamma Knife® Prototype
1986: Leksell Gamma Knife® Model U introduced
1996: Leksell Gamma Knife® B introduced
1999: Leksell Gamma Knife® C introduced
2004: Leksell Gamma Knife® 4C introduced
2006: Leksell Gamma Knife® Perfexion introduced

Perfexion = Perfect Response to Market Competition
Dose Conformity Approaches Perfect with Perfexion
A New Solution for Multi-Iso Tx = No Stop-and-Verify Required btw Isocenters
What Gives for Esprit in 2023?

FDA Approved Late 2022
Radiosurgical Devices of the Future

What I Would Like to See?

LIJUN MA
## Treatment Delivery Paradigms

<table>
<thead>
<tr>
<th>Subject /Object</th>
<th>Fix Beam</th>
<th>Move Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fix Patient</td>
<td>Uveal proton</td>
<td>Linacs</td>
</tr>
<tr>
<td>Move Patient</td>
<td>Gamma Knife &amp;…</td>
<td>TBD</td>
</tr>
</tbody>
</table>
Linac-based RT ($n \sim 1$)

Online imaging
High Dose Rate
Modular Delivery

Video Courtesy of Varian (2013)
CyberKnife: Non-Isocentric (n ~ 0)

Courtesy of
Dr. Hiroshi Tanaka & Tokyo Kamagome
LGK Perfexion: Multi-isocenters (n ~10)

Elekta (2006)
Geometric Focusing Spares the Normal Tissue Still the Best
Dose Spillage Terrible for Fan-Beam IMRT
Dose Interplays For Multi-TARGETS

Variable dose interplay effects across radiosurgical apparatus in treating multiple brain metastases
“4π” Outperforms 3 Arc-VMAT

3-arc VMAT

Geo-Optimized
“4π”
Of Course, Multi-Targets Will Need More Beams To Be Optimal

N=3

N=6

N=9

N=12
What Would I Like to See?

• We Need A Sharper Knife Leveraging Geo-Focusing
  Sharper means more Robust against uncertainties

• We Need etc, etc
Lo and behold: Zap-X

(1) Self-Shielded

(2) Best X-rays: 3-4 MV

(3) DOF: Gyro-mounting $2\pi$ delivery

(4) Rapid Beam Collimation (4 mm to 25 mm)
The Sharpest Knife One Can Get

Dose Fall-Off Approaches Theoretical Best

What’s Next: Dynamic Spot Dose Painting
Prototype Implemented on GK
30 Gy/5Fx for 5 mm PTV Margin

(Unpublished Please Keep to Yourself)
Stereotactic radiosurgery, with Gamma SRS devices or with linear accelerator systems should not be entered into lightly

-Steve Goetsch
Thank you Steve

2022 MARVIN M.D. WILLIAMS PROFESSIONAL ACHIEVEMENT AWARD

Steven Goetsch, PhD

Steven Goetsch received his Doctorate in Medical Physics from the University of Wisconsin Madison in 1983. He had previously received a BS degree in Physics from Michigan State University and an MS in Health Physics from Northwestern University. After working as a Radiation Safety Officer in the Chicago area for four years, he spent five years as a graduate student in Madison, working under Frank Herbert Attix and Paul