



## Radiosurgery an Emerging Treatment Option in Cancer Treatment and Non Cancer Condition

### KEYWORDS

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**ABSTRACT** 1. Cyberknife is emerging field of surgery where lesions which are cancerous and noncancerous lesion are effectively treated by pinpoint radiation beams.

2. Its technology, indication and advantages needs to be evaluated for application of our day to day practice of surgery as there are very few centers in India who have these machines, there has been extensive studies in west for its efficacy in different disease condition we will evaluate various publication related to this topic for our day to day practice use.

3. I have studied Cyber knife with Gamma knife, conventional radiation therapy and surgery for efficacy, advantages and condition which are treated.

### Introduction---

The Cyber Knife is based on a new category of radiotherapy techniques called IGRT (image-guided radio-therapy).

Cyber Knife robotic radio surgery technique, is so precise, that radiation beams can be sent to small, complex-shaped tumors near critical structures, such as hearing and vision nerves too. This ability to accurately focus only the tumor and protecting healthy tissue distinguishes the Cyber Knife from all other radio surgery systems and old traditional radiotherapy techniques which may be considered inoperable or untreatable.

Despite this tremendous progress in the performance of radiological and imaging techniques, the challenge remains one of early, precise and accurate detection of tumors to be treated among the body.

Keeping this whole scenario in mind, in 1987 Mr. John R. Adler, M.D., professor of neurosurgery and radiation oncology at Stanford University Medical Center was the first person who developed the Cyber Knife System after completing his fellowship in Sweden along with Lars Leksell, MD, the founder of radio surgery.

With the Cyber Knife System, Adler's vision was to develop a non-invasive robotic radio surgery system with extreme precision and superior accuracy for treatment of tumors located anywhere in the body. This revolutionary concept of Adler achieved substantial success far beyond the practice of radio surgery at the time, which had restricted radio surgery for the treatment of intracranial tumors and critical organs.

The Cyber Knife is unique in its use and applications in a manner that it uses a compact linear accelerator (LINAC) which is mounted on an image-guided robotic arm that is responsible to deliver multiple beams of high energy x-rays to a particular tumor target. The Cyber Knife accomplishes this task by cross-firing approximately 150 beams of radiation accurately at the target from multiple cross-directions. These multiple beams containing high energy radiation are delivered from multiple directions and points outside of the body and converge precisely at the tumor inside the body.

Cyber Knife System has enabled next generation of radio surgery systems to continuously track, detect and correct for tumor and patient movement throughout the treatment. This all success has been incepted by combining continual

image guidance technology, computer controlled robotics with a compact linear accelerator that has the ability to move in three dimensions according to the treatment plan. This combination, which is called as intelligent robotics, has extended the benefits of radio surgery to treat tumors located anywhere in the body.

### EXPERIMENTAL DESIGN--

#### Comparison with other modalities of radiation therapy--Table--1

CRITERIA	GAMMAKNIFE	CYBERKNIFE
Targeting Accuracy	<1 millimeter	<1 millimeter for stationary tumors < 1.5 millimeters for moving tumors
Applications	Intracranial limited soine capabilities(C1 & C2)Perfexion only	Intracranial and Extra cranial
Ability to Fractionate	Typically limited to a single fraction due to time resource and pain constraints	Unlimited
Image Guidance	None, relies exclusively on target's fixed relative position to the stereotactic frame mechanical accuracy may introduce 1.2-1.9 mm error(Macianas)	Continual image guidance through the treatment high resolution kv imaging automatically track, detect and correct for tumor and patient movement
Non-Coplanar Delivery Capabilities	Hemisphere with fixed collimators enables a non-coplanar workspace capable of delivering a maximum of 201 (190 perfexion)unique beam angels	Robotic mobility enables a large non-coplanar workspace capable of seamlessly delivering more than 1200 unique beam angles without treatment interruption or the need to manually reposition the patient
Moving Tumor Targeting	NA	Delivery tightly contoured beams synchronized precisely to tumor motion resulting in minimal healthy tissue exposure
Stereotactic Frames	Require invasive frames in all cases	No frame required

**Additional advantages:-Table-2**

CRITERIA	GAMMA KNIFE	CYBERKNIFE
ADDITIONAL COST FOR RADIATION	Need replacing radiation sources	Not needed
RADIATION SOURCES	Expensive	
DRILLING OF STEREOTACTIC FRAME	Needed	Not needed for less
TECHNOLOGY TYPE	40 year old	Recently introduced
AFFORDABILITY	Expensive	Cost effective
TYPE OF TUMOUR	Only cns tumor	Tumor of any part of body
SIZE OF TUMORS	Better for less than 4 cm	Can treat larger than 4 cms

**CONVENTIONAL RADIOTHERAPY VS CYBERKNIFE:-Table-3**

Criteria	Conventional Radiotherapy	Cyber knife
Total No Of Beams	30-45 degree to each other two beams	150 beams
Accuracy	wide field needed	sub millimeter accuracy
Duration Of Treatment	needs 5-6 weeks with 5 day/week and of 2 days interval	3-5 days
Radiation Resistant Rcc/Sarcoma/Melanoma	not able to treat	can better treated
Size Of Tumor	better for less than 4 cms	more than 4 cms
Tumor Control	partial repair of tumor due to small doses	better control as no recovery Over 6 weeks
Movement During Radiation	not get adjusted so wide area of radiation field	got adjusted, so pinpoint radiation with 5 mm accuracy
Surrounding Tissue	affected	not affected

**SURGERY VS CYBERKNIFE- Table-4**

Criteria	SURGERY	CYBERKNIFE
Type of tumor Treated	all operable tumors	patient unfit ,Residual tumor after surgical excision
Morbidity/mortality	present with every surgery	Least
Recurrent tumor	high chances	reduces the chances of recurrence

**Discussion—**

Note: Outcomes of Cyber knife treatment would vary from patient to patient and also on case to case.

We will discuss the potential advantage of Cyber knife with Gamma knife, conventional radiotherapy and surgical management.

- Treats inoperable tumors
- Stereotactic blood-less radio surgery
- Treats tumors anywhere in the body
- Pinpoint accuracy
- Dynamic motion tracking
- Highest level of comfort
- Pain- free
- No anesthesia

- No invasive head or body frame
- No breath-holding during treatment
- Superior quality of life
- Significantly reduces treatment time
- Treats only affected areas
- Minimizes side effects
- Immediate return to normal activity
- Non-invasive and pain-free
- Cyber Knife offers a pain-free, non-invasive approach to radio surgery that result in fewer complications than open surgery with comparable results.

**➤ No invasive body or head frame**

Owing to the accuracy of the targeting system, the patient is not held down by uncomfortable frames or braces to restrict movement. Cyber Knife zeroes in and sets its target on the affected area, automatically correcting for any movements made by the patient or the tumor. Unlike conventional radiotherapy, the Cyber Knife system uses the skeletal structure of the body, rather than invasive metal frames and skull pins, as a reference point for identifying the tumor position throughout the treatment. This allows the patient to settle comfortably during the treatment.

**➤ Significantly reduces treatment time**

The treatment duration is reduced significantly from about 5-6 weeks to a maximum of 5 days with one session per day, lasting about 30-90 minutes.

**➤ Little or no recovery time**

Patients can return immediately to their normal routine after the session is over. The treatment can be performed as an outpatient procedure.

**➤ Minimizes side effects**

Since Cyber Knife targets only the affected areas with a high degree of precision there is minimal possible exposure to healthy cells by the radiation. The intensity of each individual beam isn't high; however the combined energy of the beams targets the cancerous tissue with the least possible effect on healthy organs hence, side effects are minimized.

**➤ Treats inoperable tumors**

Using a fully integrated robotic delivery system, Cyber Knife allows far superior reach and maneuverability to previously inaccessible and inoperable lesions such as lesions involving the spine, optic apparatus and pancreas. Robotic flexibility allows for isocentric as well as non isocentric treatment. Cyber Knife can treat tumors anywhere in the body, including prostate, lung, brain, spine, liver, pancreas and kidney.

**➤ Pinpoint accuracy**

Cyber Knife is unmatched by any other radiation therapy and radio surgery system when it comes to accuracy. The system can essentially target only the affected area, sparing surrounding healthy tissue, minimizing painful side-effects. Multiple beams of high-energy radiation can be delivered from up to 1200 angles to converge precisely on the tumor or lesion.

**➤ Dynamic motion tracking**

Cyber Knife uses real-time image guidance software to continually track and adjust for movement during treatment. It confirms tumor location prior to beam delivery, making it possible to treat lesions that move with respiration such as lung and pancreas tumors. The computer system is able to tell the Cyber Knife robot not only where the tumor is, but where it is in relation to the breathing cycle. It allows doctors to treat even small areas accurately because the robot synchronizes with the patient's breathing. This allows the patient to breathe easily and relax throughout the procedure.

**➤ Higher radiation does possible**

Many patients who previously reached the lifetime dose limit of traditional radiation therapy to critical structures/tissues

can receive additional treatment with Cyber Knife because of its targeted treatment precision. Gold seed implants near the tumor may be needed some cases.

We will discuss indication of Cyberknife for treatment various condition effectively as compared to other modalities of treatment-----

#### EXTRACRANIAL Condition

##### Spine---

- Selected solitary metastases without bony spinal cord compression
- Primary treatment of classically radio resistant solitary tumors, i.e., melanoma, renal cell, sarcoma
- Recurrent solitary metastases after conventional Radiotherapy

##### Lung---

- Stage I NSCLC if medically inoperable or if patient refuses open surgery
- Advanced stage NSCLC as a boost treatment
- Up-front treatment of obstructing endo bronchial lesion with post-obstructive pneumonia
- Metastases: solitary or limited (2-5) multiple metastases if symptomatic or enlarging on serial imaging with a favorable survival profile

##### Liver---

- Metastases: solitary or limited (2-5) multiple metastases if symptomatic or enlarging on serial imaging with a favorable survival profile

##### Pancreas---

- Up-front radiosurgery treatment of unresectable tumor "sandwiched" between chemotherapy doses
- Boost treatment for persistent PET-positive region after conventional chemotherapy and radiation therapy

##### Renal---

- Renal cell cancer in medically inoperable patients

##### ENT--

- Recurrent or residual head and neck tumors after conventional treatment

##### Prostate---

- Low-risk prostate cancer as an alternative to multi-week IMRT, low-dose brachytherapy or high-dose brachytherapy (HDR)

##### OB-GYN---

- For vaginal cuffs as primary or as boost

#### GENERAL Condition---

- As an adjunct or planned "boost" after conventional external beam radiation therapy (XRT)
- As an alternative to conventional XRT, especially for radio resistant tumors
- For tumor recurrence in previously irradiated regions. These patients usually have no other option.

- As an alternative to conventional surgery:
  - Equivalent outcomes in some cases
  - Medical condition may preclude surgery
  - Patient preference is a large factor

#### INTRACRANIAL Condition

##### Benign Tumors---

- Meningioma
- Pituitary Adenoma
- Acoustic Neuroma
- Other Cranial Nerve Schwannomas
- Glomus Jugulare Tumors
- Residual / recurrent low-grade Astrocytoma, Oligodendroglioma, Hemangioblastoma

##### Malignant Tumors---

- Metastatic Tumors
- Malignant Gliomas

##### Vascular Lesions---

- Arteriovenous Malformations (AVM)
- Cavernous Malformations/AOVM

##### Functional Disorders----

- Trigeminal Neuralgia
- Cluster Headache
- Vim Thalamotomy for tremor

#### Results---

Cyberknife is recently introduces technique of radiation treatment called IGRS- image guided radiation therapy --robotic assisted linear accelerator with pinpoint radiation beam.

It is much advanced technique of radiation compared to Gamma knife, conventional radiation.

Due to pinpoint accuracy, collateral damage to neighboring normal tissue is avoided so most of tumors located near the critical structure like optic nerve or major vessel which were previously non treatable now can easily treated by cyber knife .

Also Cyber knife can be used for radiation treatment for tumor located anywhere in body as compared other radiation sources which have some limitation like Gamma knife used only for CNS tumor and conventional radiation can not used in areas like eyes, cns, major vessels.

Certain non malignant condition like Arterio venous malformation in CNS ,or Trigeminal neuralgia difficult to treat surgically can now easily treated by cyber knife.

#### CONCLUSION----

*Cyber knife therapy has emerged as effective radiation therapy over traditional radiotherapy modalities as well as effective alternative treatment to surgery in cases of malignancy and non cancer patients where surgery is not possible because of multiple reasons.*

#### REFERENCE

Cancerresearchuk.org---treatment with cyber knife stereotactic radiotherapy | Pennmedicine.org---noninvasive alternative to surgery for cancerous and noncancerous condition | Ucsfhealth.org---cyber knife | Hgoncology.com---advantages of cyber knife technology | Cyber-knife.net---safe and innovative technique | Accuracy.com---cyber knife treatment delivery | Cyberknife.com---giving new hope to patient with cancer | Standfordhospital.org---cyber knife treatment