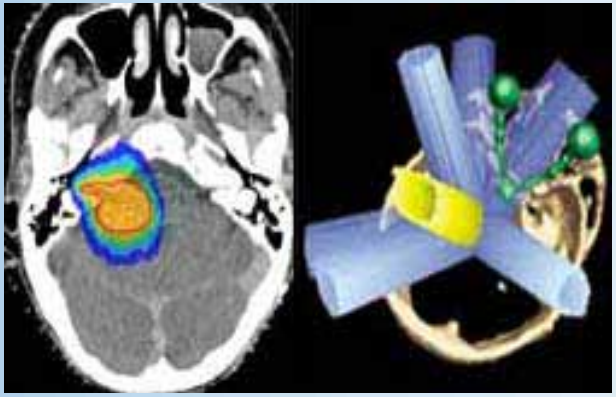
Radiation Treatment

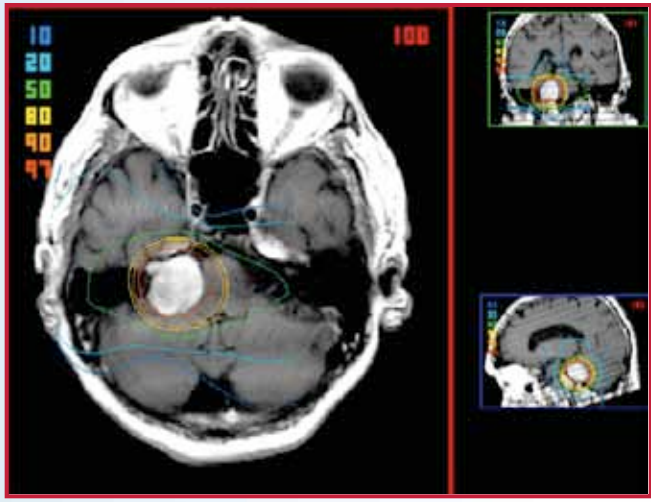


Jess Guarnaschelli, MD

Radiation Oncologist, UC Brain Tumor Center

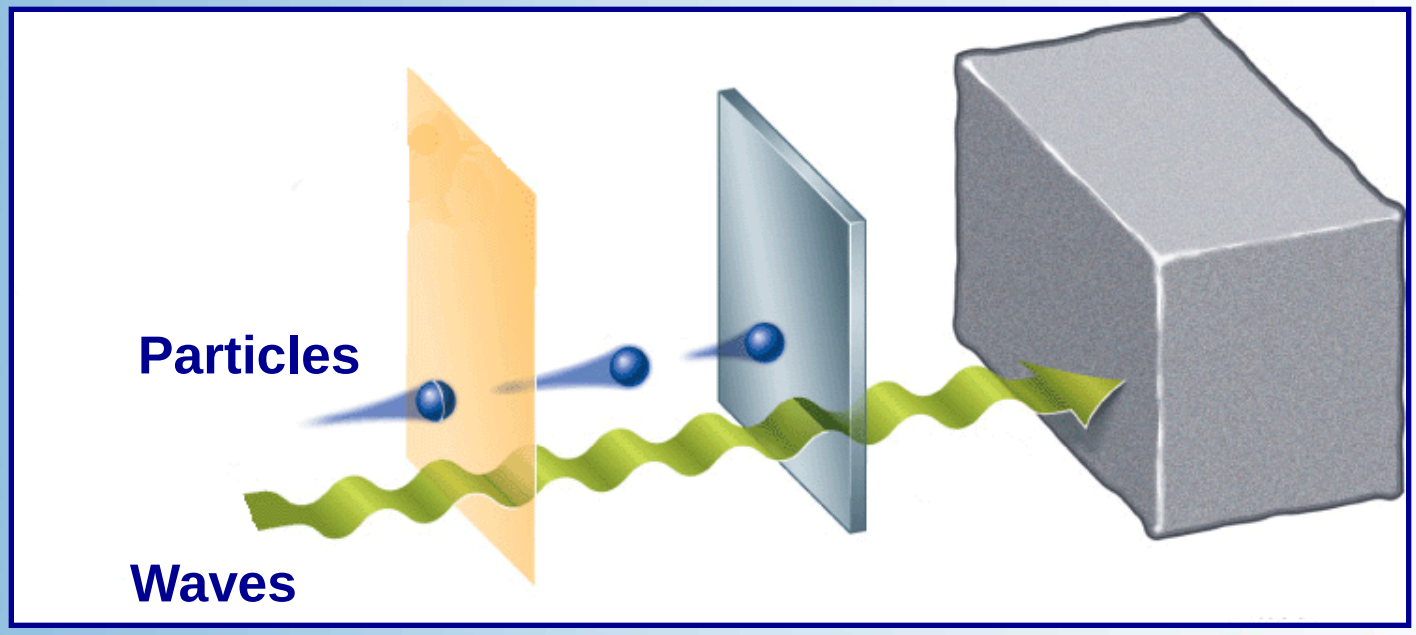
Acoustic Treatment Options

- **Observation (watch & wait)**
- **Surgery**
  - Middle fossa
  - Translabyrinthine
  - Suboccipital
- **Radiation**
  - Stereotactic radiosurgery
  - Fractionated radiotherapy



What is Radiation?

Traveling energy packets which transfer energy upon contact with matter

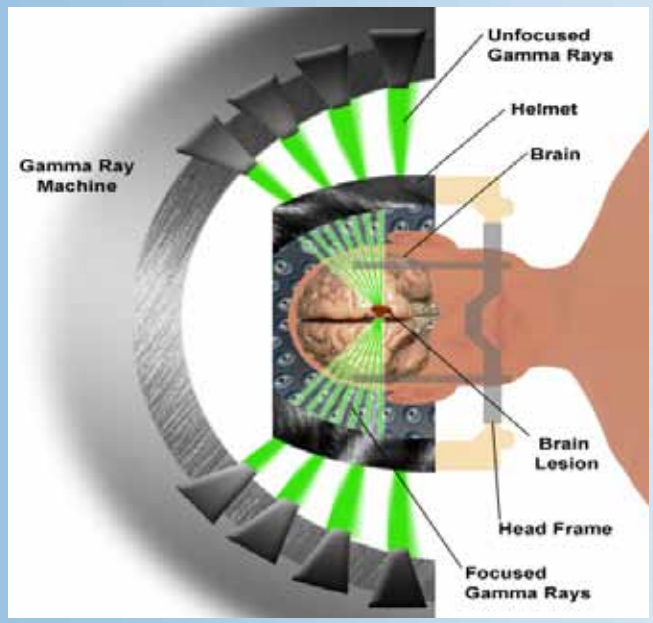


Gamma knife: Cobalt Radiation

Fixed Cobalt-60 sources

Technology: Gamma Knife

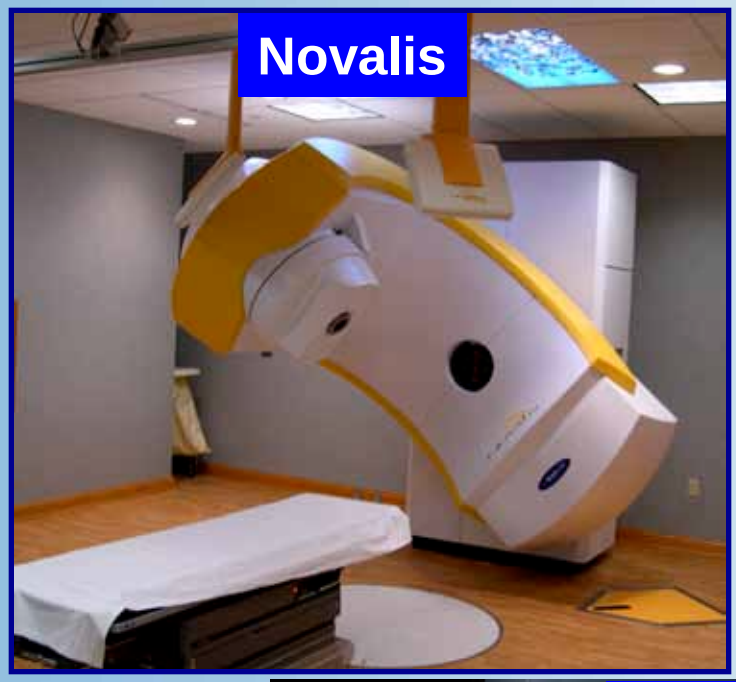
- Old design: 201 fixed cobalt 60 sources
- Perfexion is the latest design
- Fully automated with robotic interface with192 fixed cobalt-60 sources



Technology: Linear Accelerator

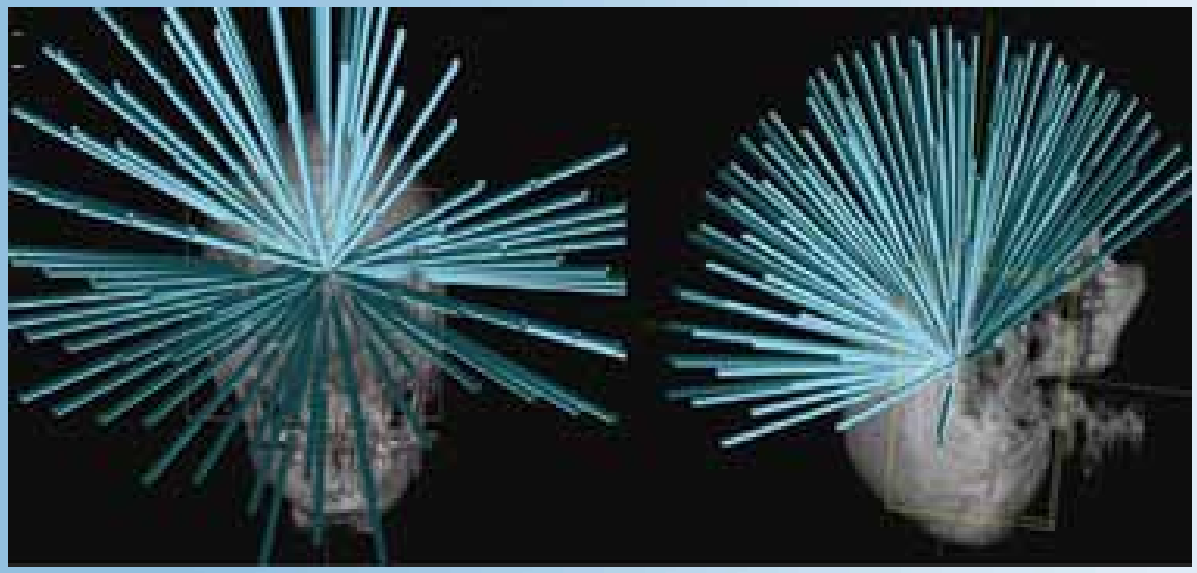
- Machine moves around patient in arcs aiming beams at the tumor
- Does not always require use of a head frame attached to the skull
- “Frameless” face mask
- Requires a custom aquaplast mask fitting

Linear Accelerators



Cyberknife

- CyberKnife G4 is the latest design
- Robotic compact 6 mV linear accelerator
- 12 interchangeable circular collimators delivering “pencil beam” radiation

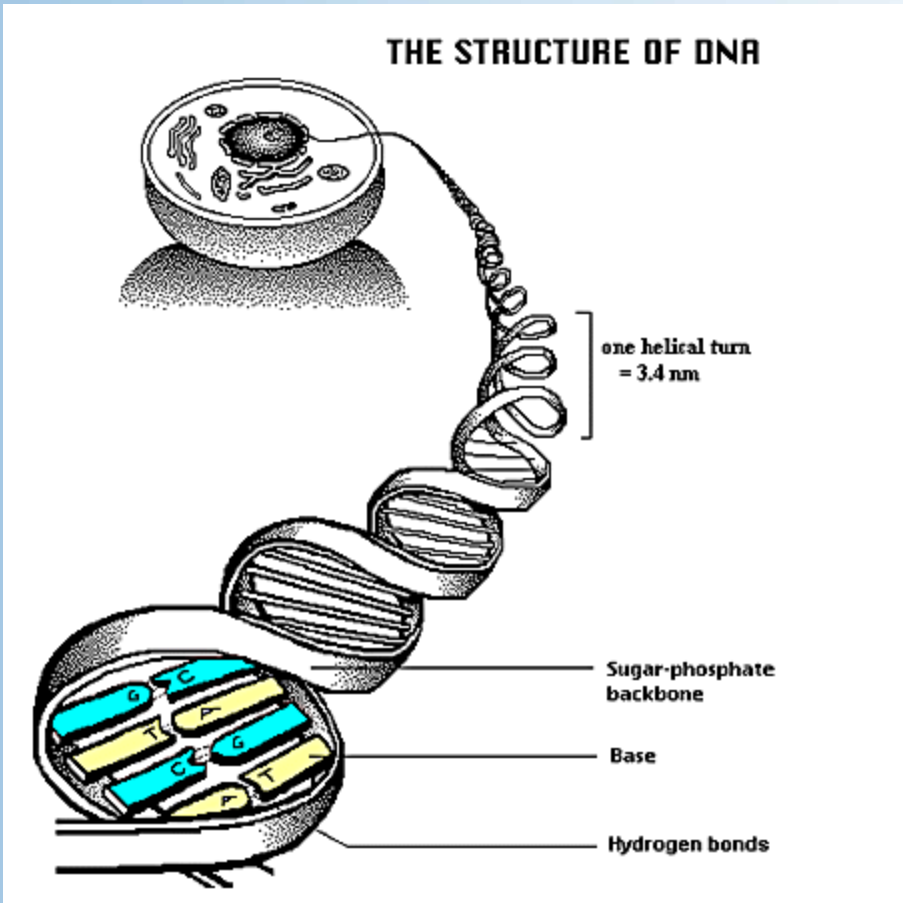


Novalis machine

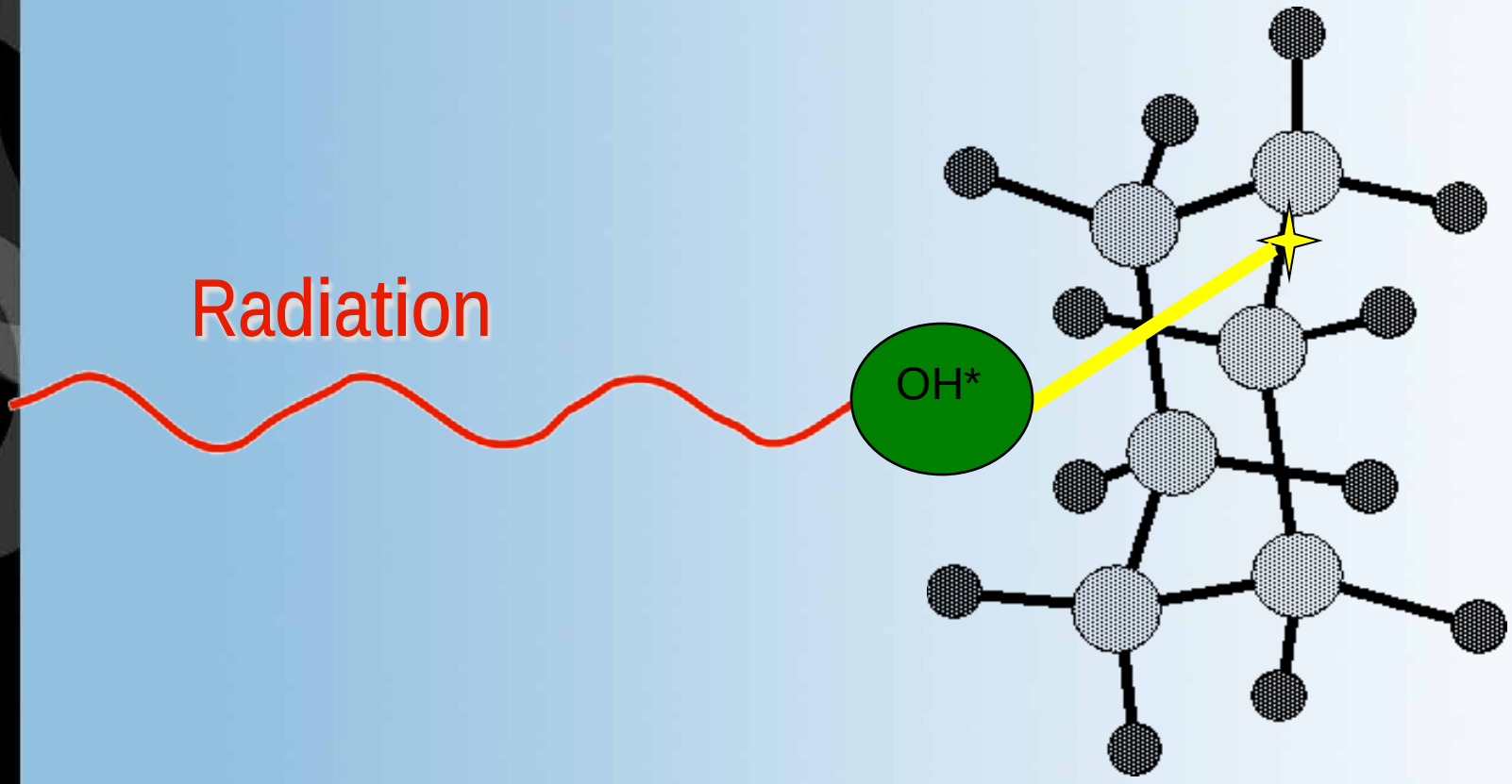
- Novalis TX is the latest design
- Robotic couch
- Micro-multileaf collimation: more leaves for radiation beam shaping, larger primary collimation port

How Does Radiation Kill Tumor Cells?

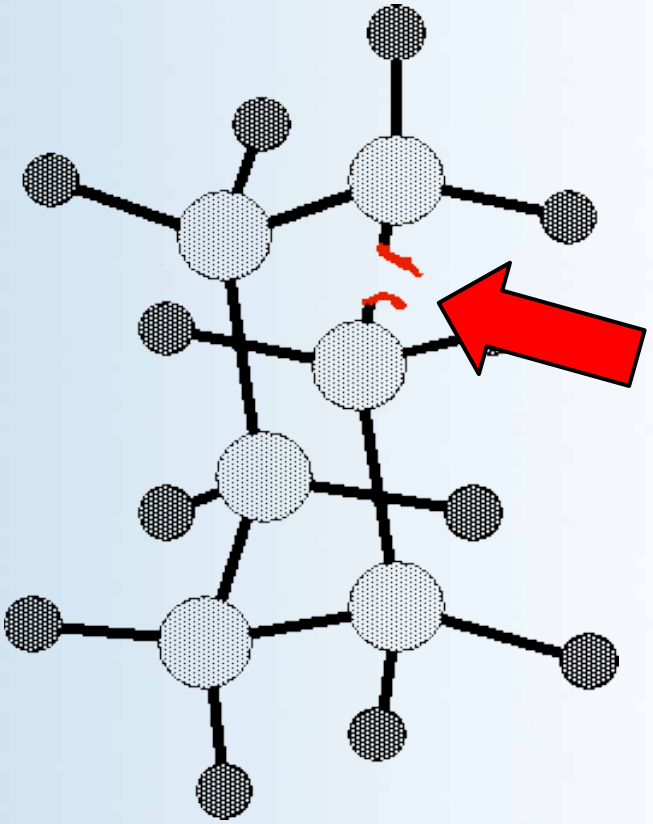
Tumor Cell DNA is the Target for Radiation



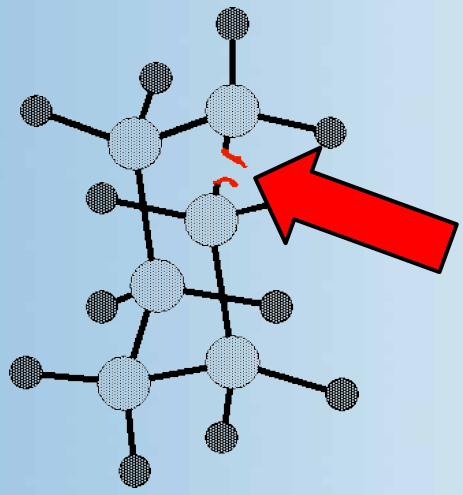
Radiation delivers energy to the tumor cell DNA



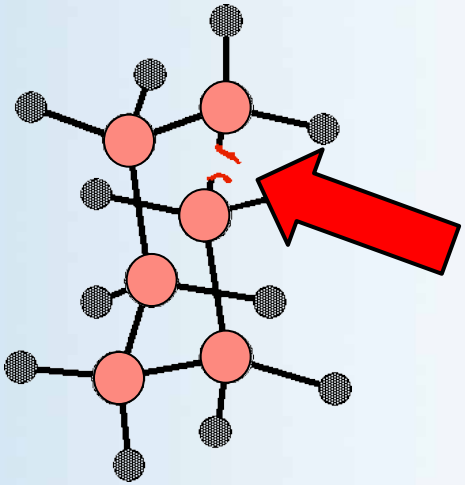
Which damages the tumor DNA



Tumor cells are unable to repair DNA damage (unlike normal brain cells)



Normal brain cell DNA



Tumor cell DNA

Two radiation strategies for treating acoustic neuromas:

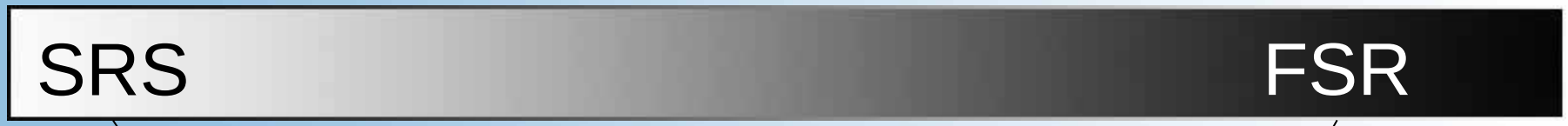
- **Stereotactic radiosurgery (SRS)**
  - High dose of radiation in a single session
- **Fractionated radiotherapy (FRT)**
  - Low doses of radiation delivered in multiple sessions

Gamma Knife

Linac

Novalis and Gamma Knife

Novalis and Cyberknife

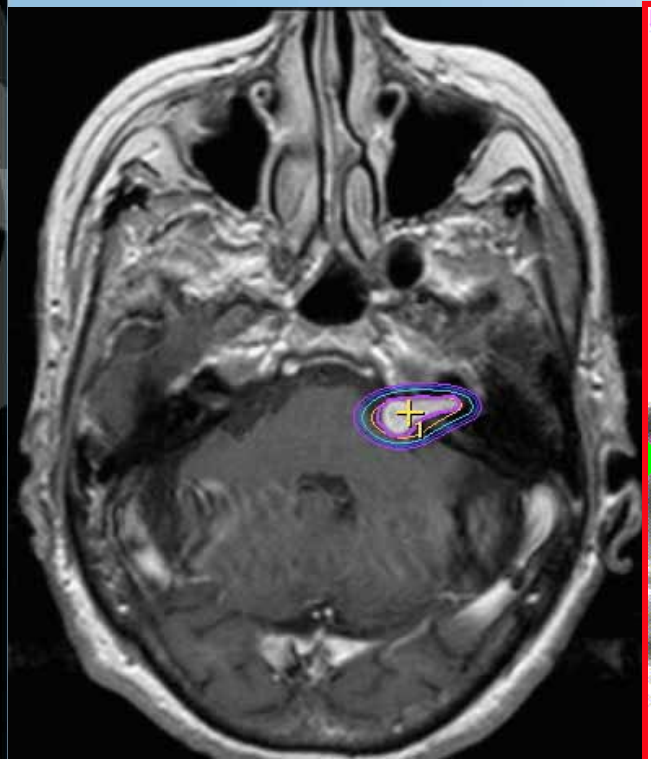


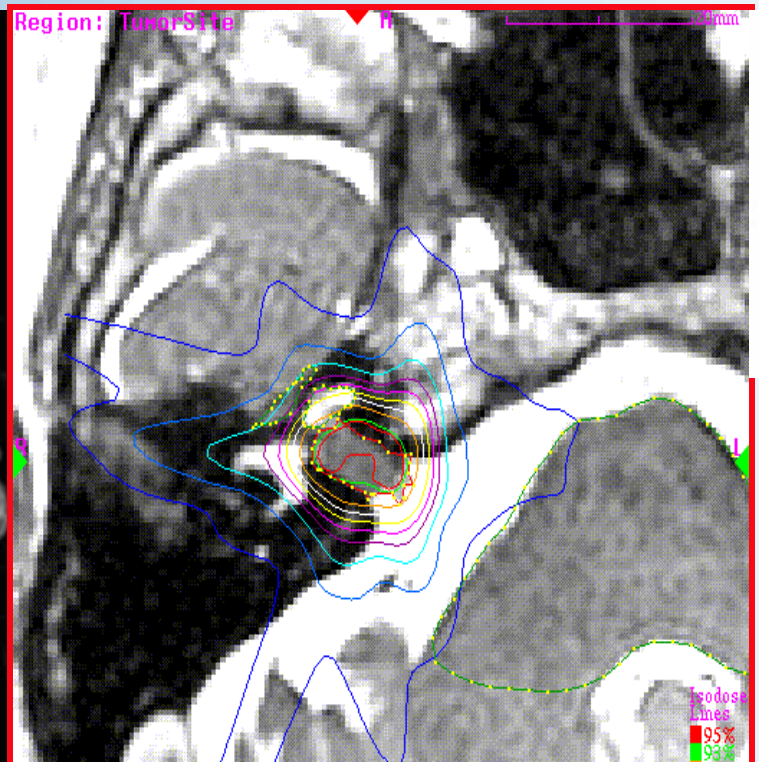
Cranial base tumors ***not*** near or involving special sensory cranial nerves

Cranial base tumors ***near or involving*** special sensory cranial nerves

Stereotactic RadioSURGERY

- **Stereotactic Radio<u>SURGERY</u> (Single Treatment)**
  - Use of highly focused beams of radiation that are precisely targeted using stereotactic techniques
  - Large, single dose concentrated on the tumor (12-24 Gy)
  - Rapid fall-off resulting in a low dose to normal tissues





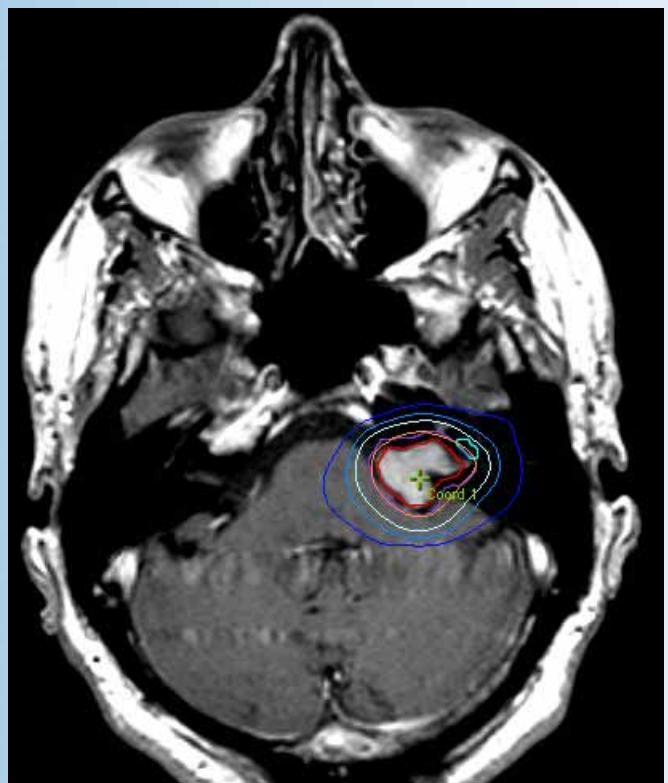
Stereotactic radiosurgery results

	SRS (10-20 Gy)
Tumor control (10 year follow-up)	91-100%
Hearing preservation	35-71%
Loss facial strength	<1%
Facial numbness	<3%

Flickinger JC Radiother Oncol 1993
Lunsford LD J Neurosurgery 2005
Murphy ES IJROBP 2011

Stereotactic RadioTHERAPY

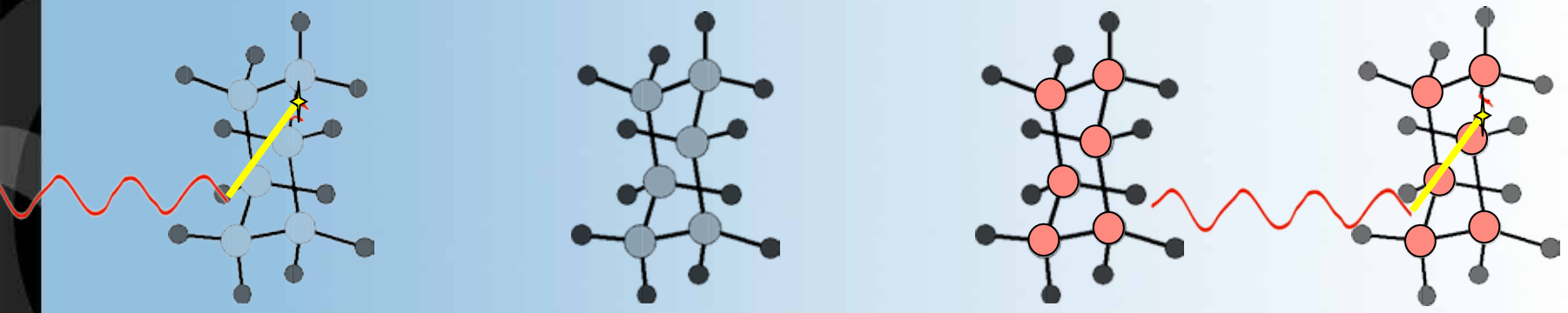
- **Stereotactic RadioTHERAPY (Multiple Fractions)**
  - Use of broader fields of radiation delivered over multiple sessions (usually 26 days)
  - Multiple, smaller doses (180 cGy) to a total dose of 4680
  - Adjacent normal tissue receives the same dose as tumor



What is Fractionated Radiotherapy?

- Low doses of radiation delivered in “fractions”
- Multiple consecutive daily treatments
- Requires the fitting of an aquaplast mask
- Does not require use of a head frame attached to the skull

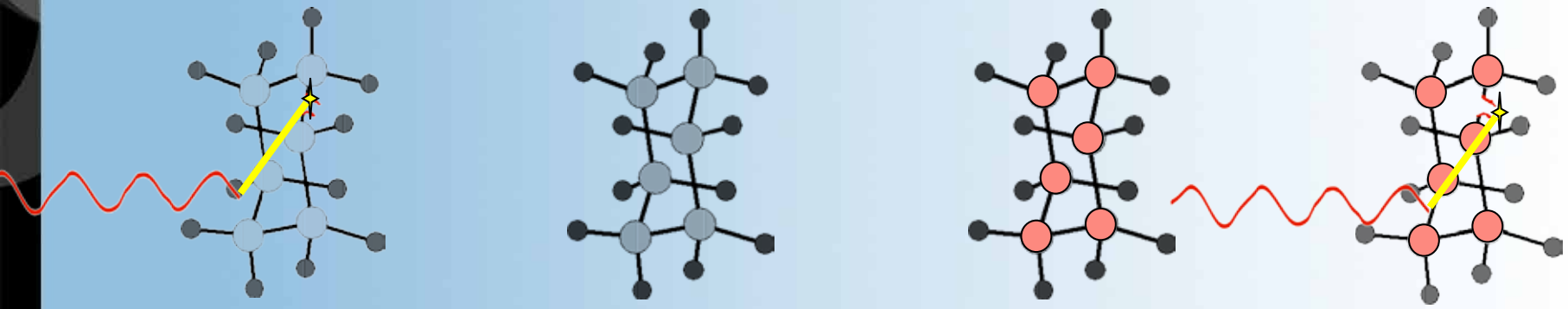
Stereotactic Radiotherapy: small doses of daily radiation



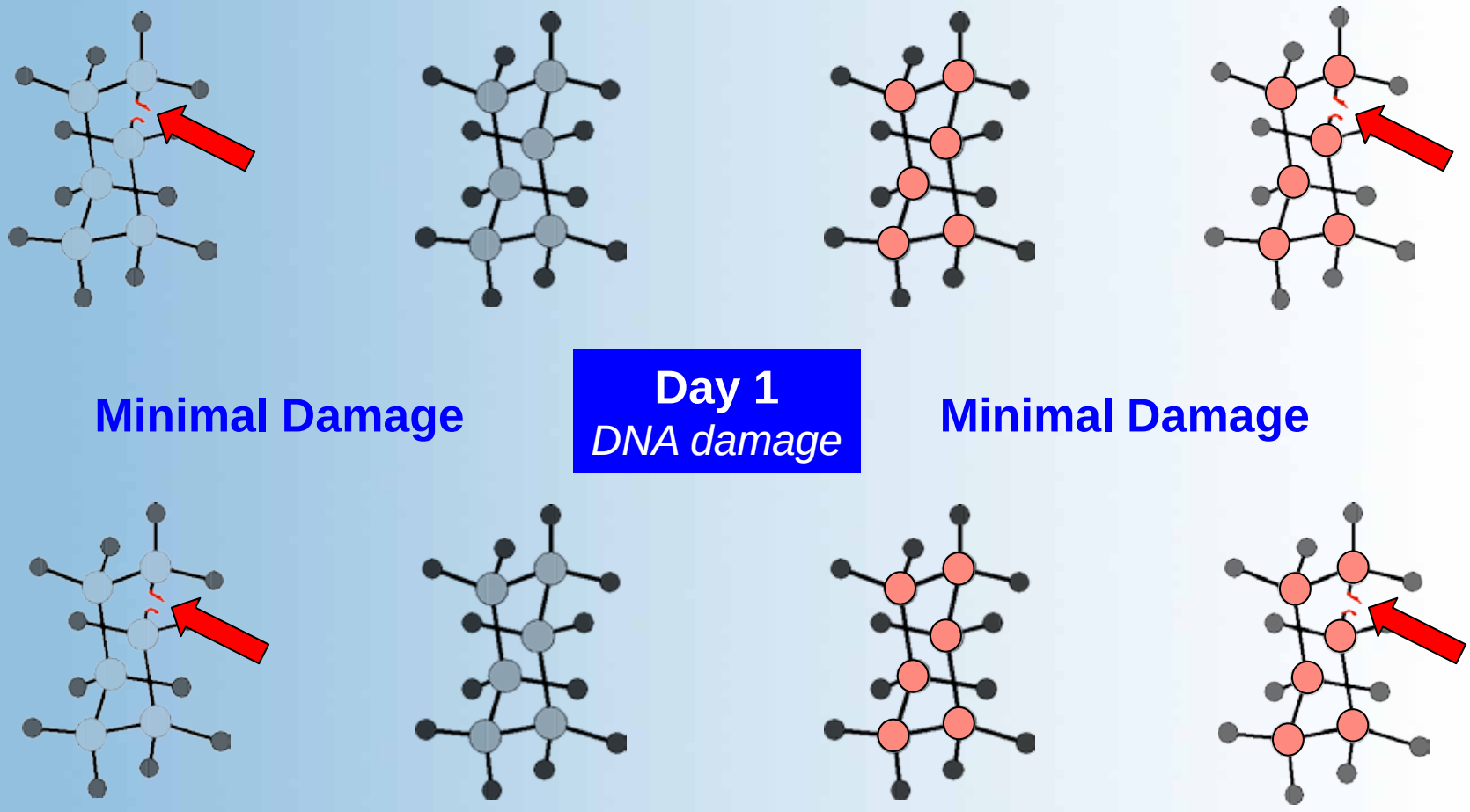
Low Dose

Day 1
Radiation delivery

Low Dose



Stereotactic Radiotherapy: small doses of daily radiation

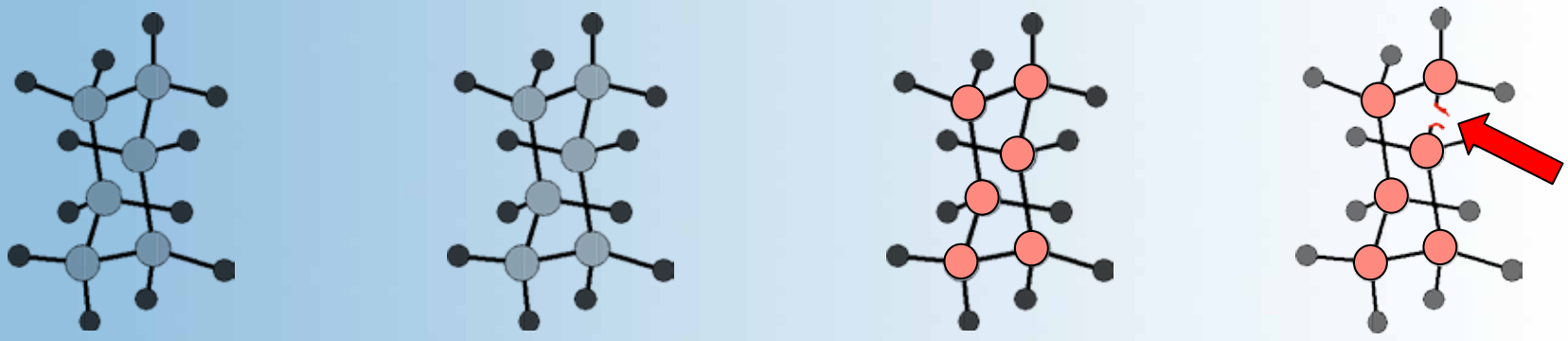


Minimal Damage

Day 1
DNA damage

Minimal Damage

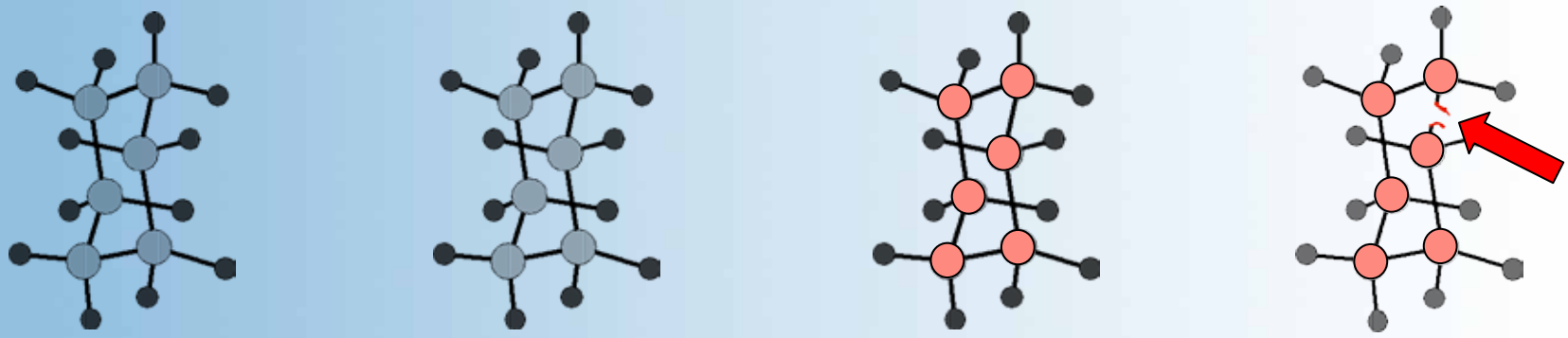
Stereotactic Radiotherapy: small doses of radiation daily



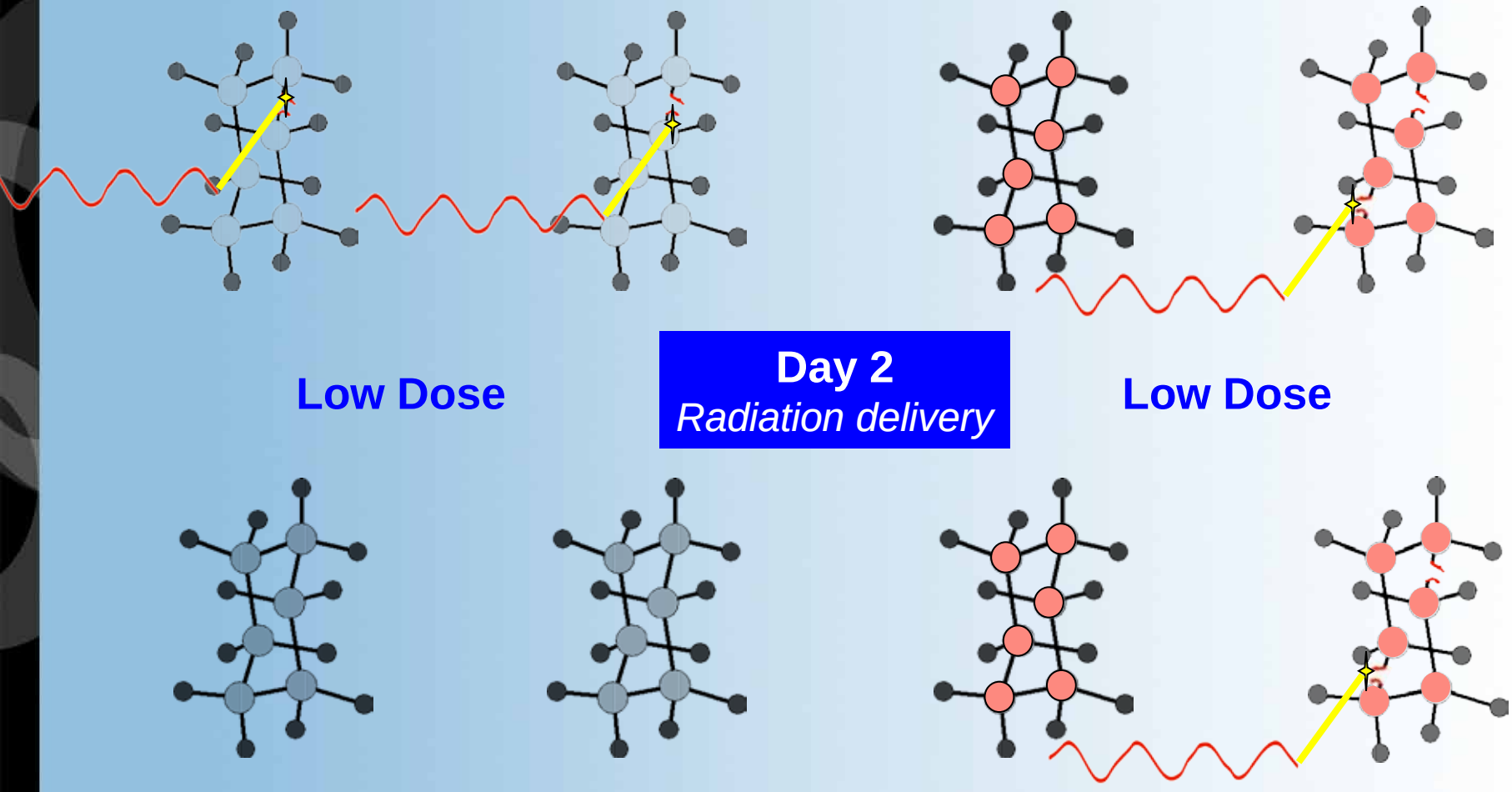
Repaired

Day 2
DNA repair

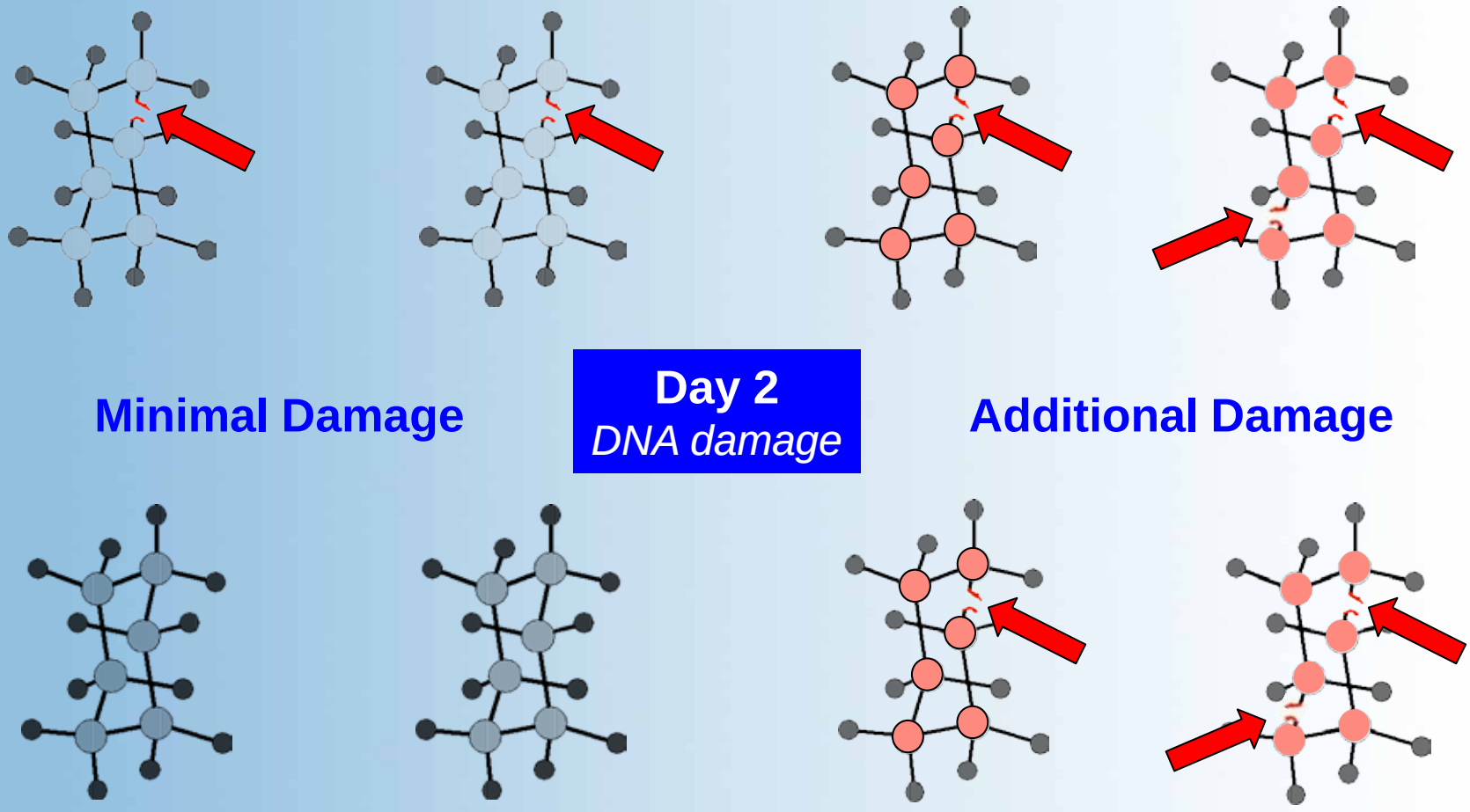
Not repaired



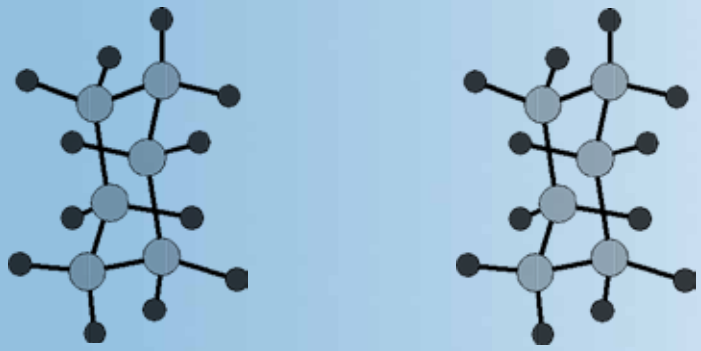
Stereotactic Radiotherapy: small doses of radiation daily



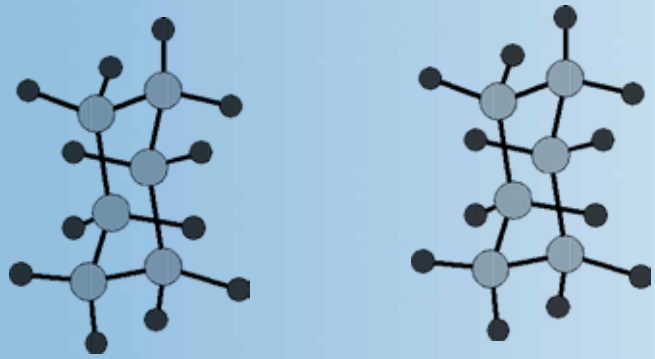
Stereotactic Radiotherapy: small doses of radiation daily



Stereotactic radiotherapy: small doses accumulate and result in tumor cell death



26 daily fractions → **Tumor Death**



How Do Tumors Shrink After Radiation?

The Rate of Tumor Shrinkage After Radiation is Correlated with Rate of Tumor Growth Prior to Radiation

Metastatic Tumor (e.g., breast cancer)

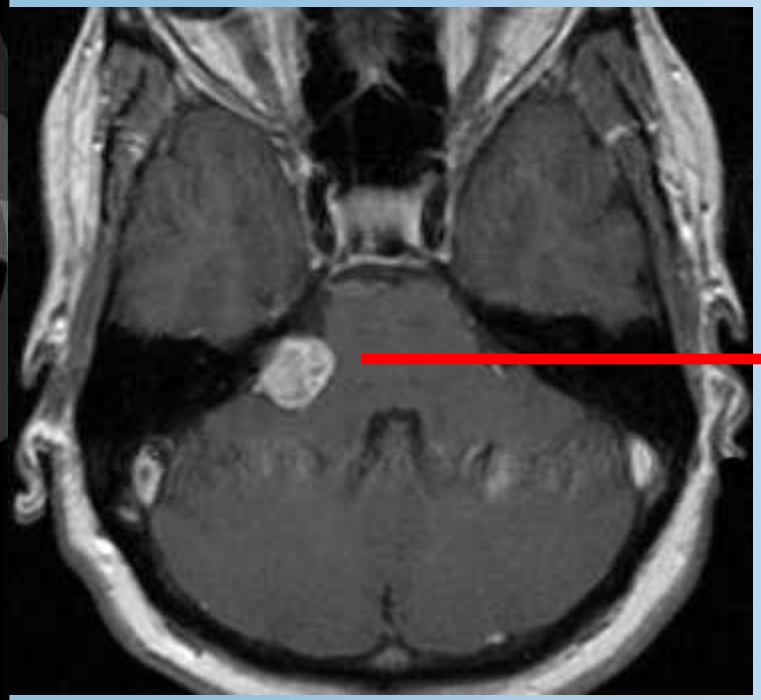
Fast growing tumor è fast shrinkage

3 months

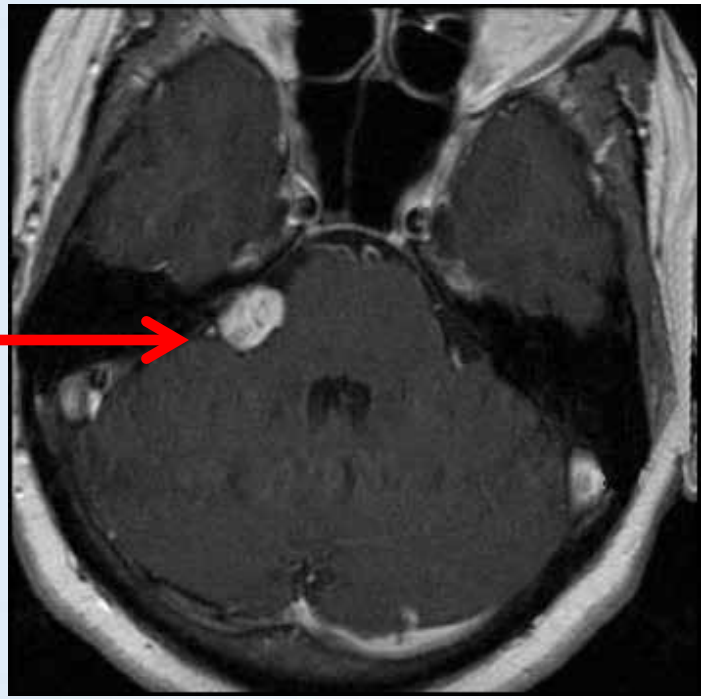
The Rate of Tumor Shrinkage After Radiation is Correlated with Rate of Tumor Growth Prior to Radiation

Acoustic Neuroma

Slow growing tumor è slow shrinkage

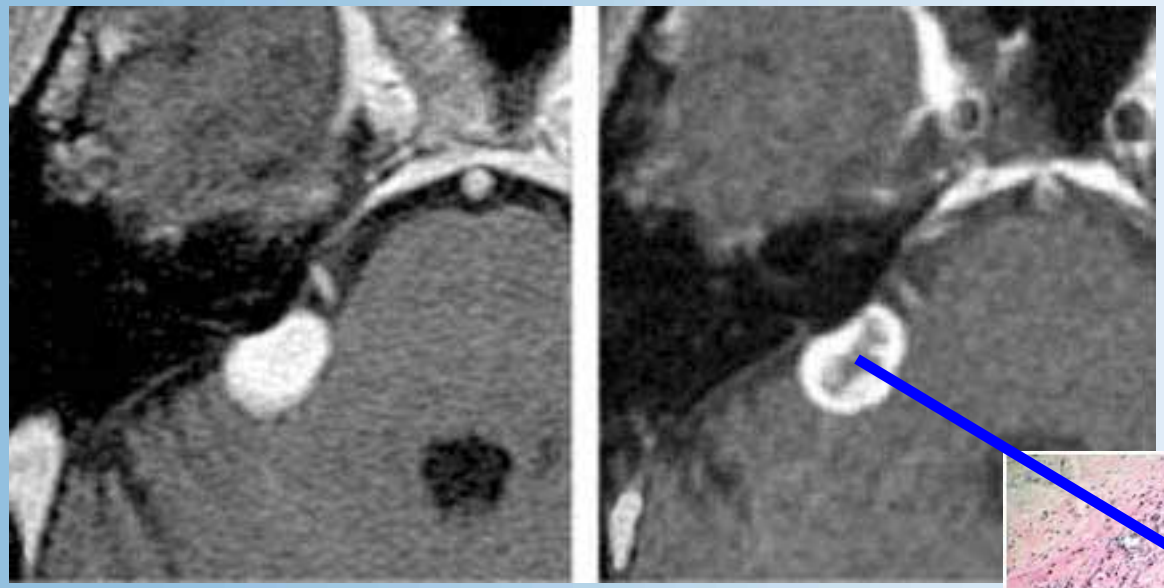


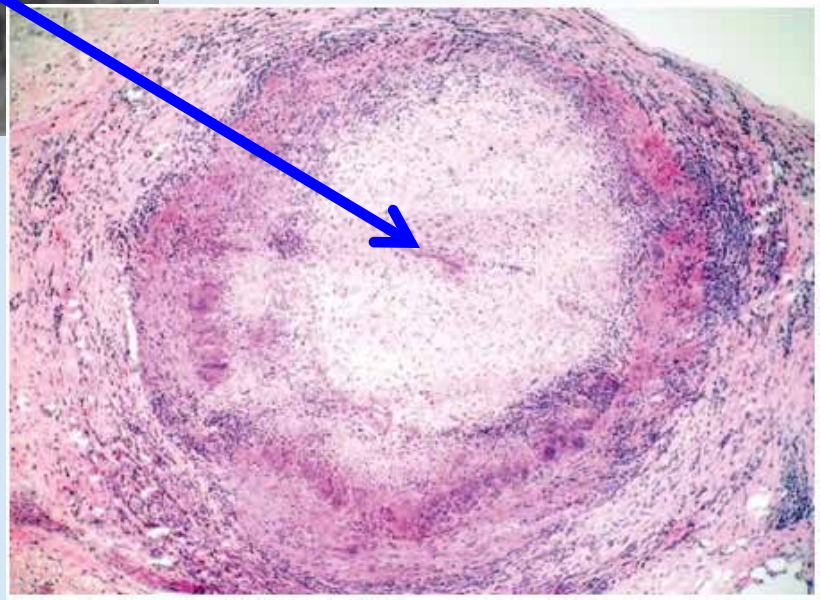
3 years



Mechanisms of Tumor Shrinkage After Radiation Therapy

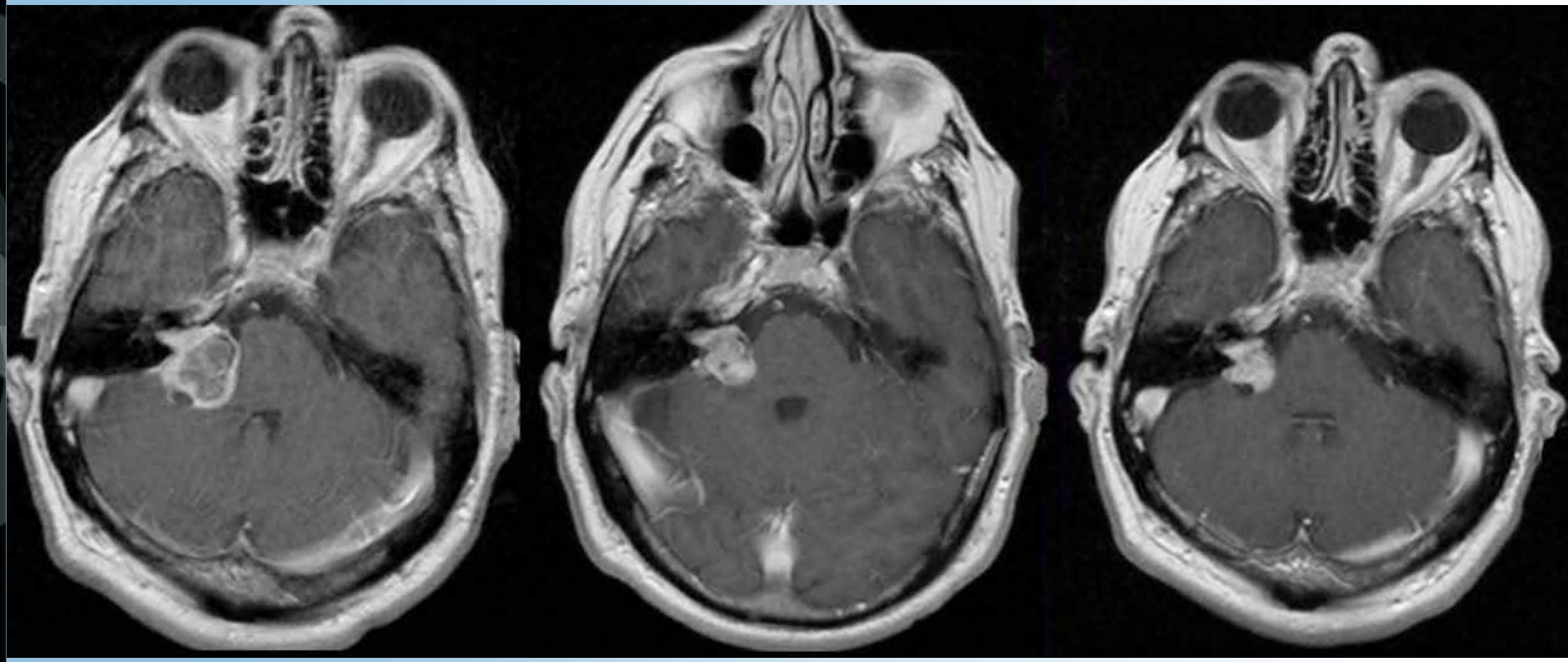
Tumor cell death è necrosis (debris)





Mechanisms of Acoustic Neuroma Shrinkage Radiation

Gradual shrinkage over time



SRS versus FRT

	SRS	FRT
Tumor control	91-100%	91-100%
Useful hearing preservation	35-71%	63-100%
Facial strength loss	1%	1%
Facial numbness	5%	0%

Tumor control is equivalent with SRS and FRT, but greater hearing preservation rate with FRT

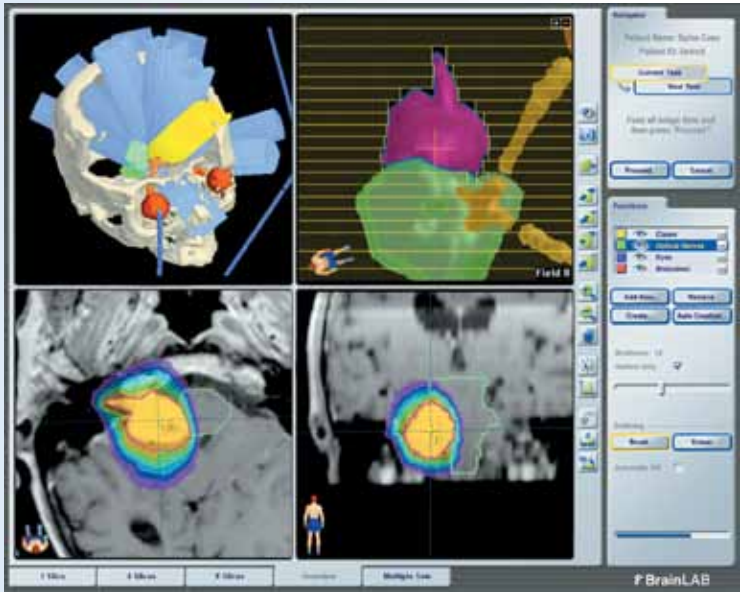
Murphy E, IJROBP, 2011
Andrews D, IJROBP, 2009

Side effects of radiation

- Hearing loss
- Facial paralysis - loss of muscle control on one side of face
- Facial numbness
- Headaches
- Dizziness
- Brain Swelling (cerebral edema)
- Skin irritation
- Hair loss (alopecia)
- Remote possibility of inducing secondary malignancy

How can we Improve Outcomes in The Future?

- Total dose (limited by critical structures)
- Change number of fractions
- Protect normal brain from radiation, eliminate dose to normal tissue (e.g., dose shaping)
  with preserved hearing
  -



Andrews, Int J Radiat Oncol Biol Phys 74(2):419-26, 2009

Recommendations

- Radiation is a treatment option for a select group of patients
- SRS and FRT can be utilized
- FRT has equivalent tumor control and improved useful hearing preservation
- Patients with larger tumors, young age, or significant hearing impairment are candidates for early rather than delayed therapy

Acknowledgements

- **Medical Physics**
  - Michael Lamba, Ph.D.
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  - John Tew M.D.
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