Eye Lens Dosimetry in Radiotherapy Using a Contact Lens-Shaped Applicator

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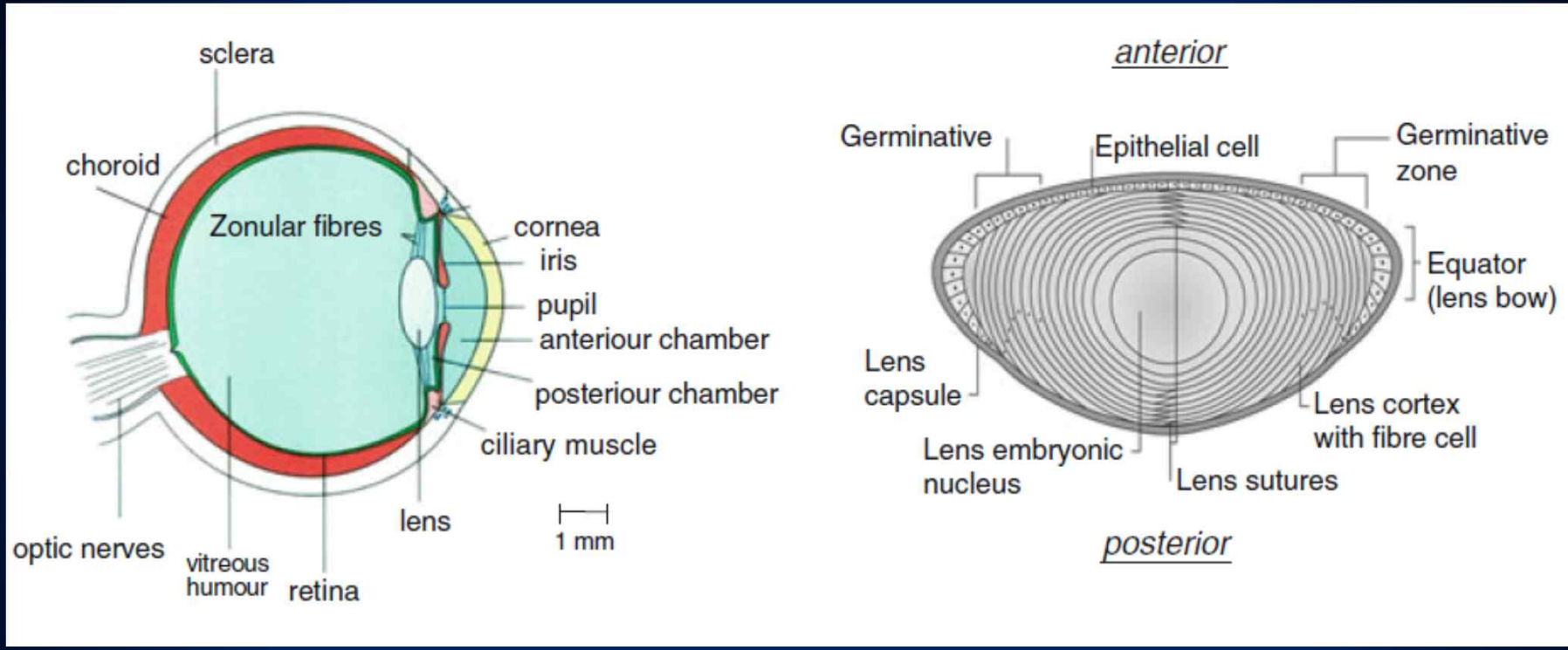
Eye lens



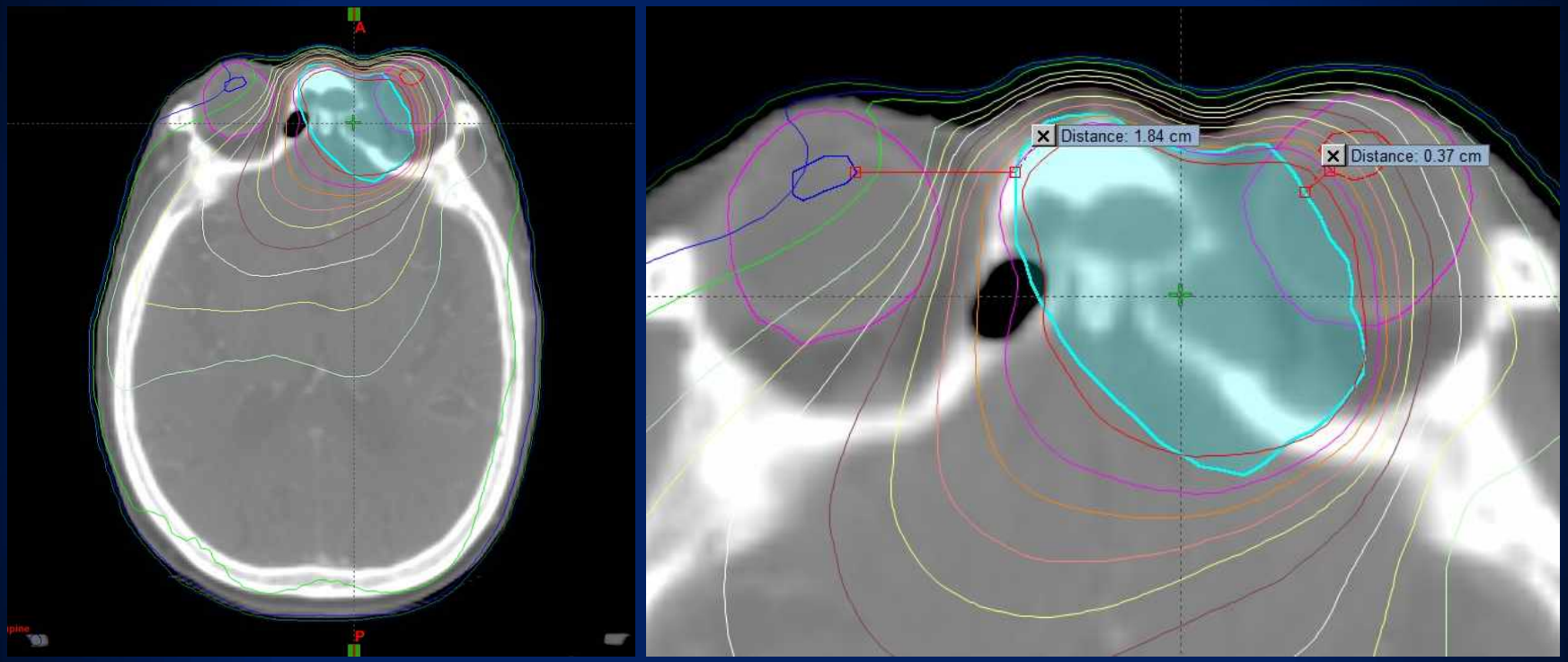
- Volume = ~ 0.216 cm^3
- Located at a depth of about 3 mm
- Highly sensitive to radiation

Charles MW and Brown N. Dimensions of the human eye relevant to radiation protection. Phys Med Biol. 1975;20:202-218

Eye lens dose in radiotherapy

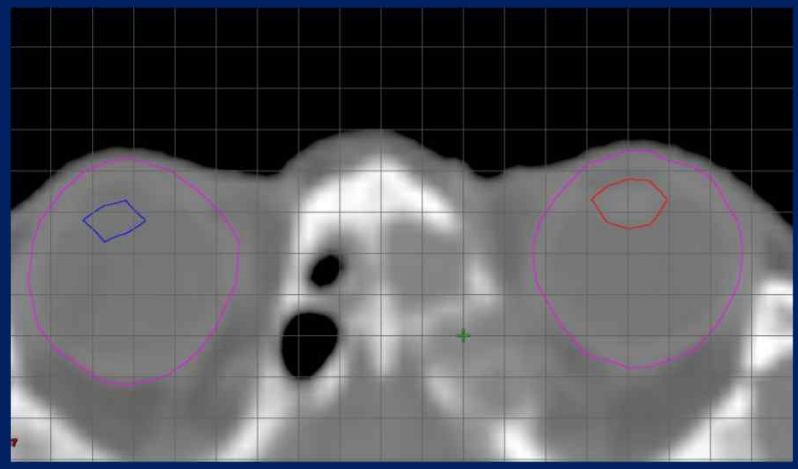
- Unlike irradiation of eye lens in radiology and cardiology,
  - Very high doses might be delivered to eye lenses during radiotherapy
    - Especially when eye lenses are located near the target volume
  - We can calculate delivered dose to eye lens with TPS, however, it might be inaccurate
  - Steep dose gradients could occur near the eye lenses
    - Small misalignments may result in differences between calculation and delivery
    - Eye movement during radiotherapy could result in high dose irradiation of the eye lens

Example



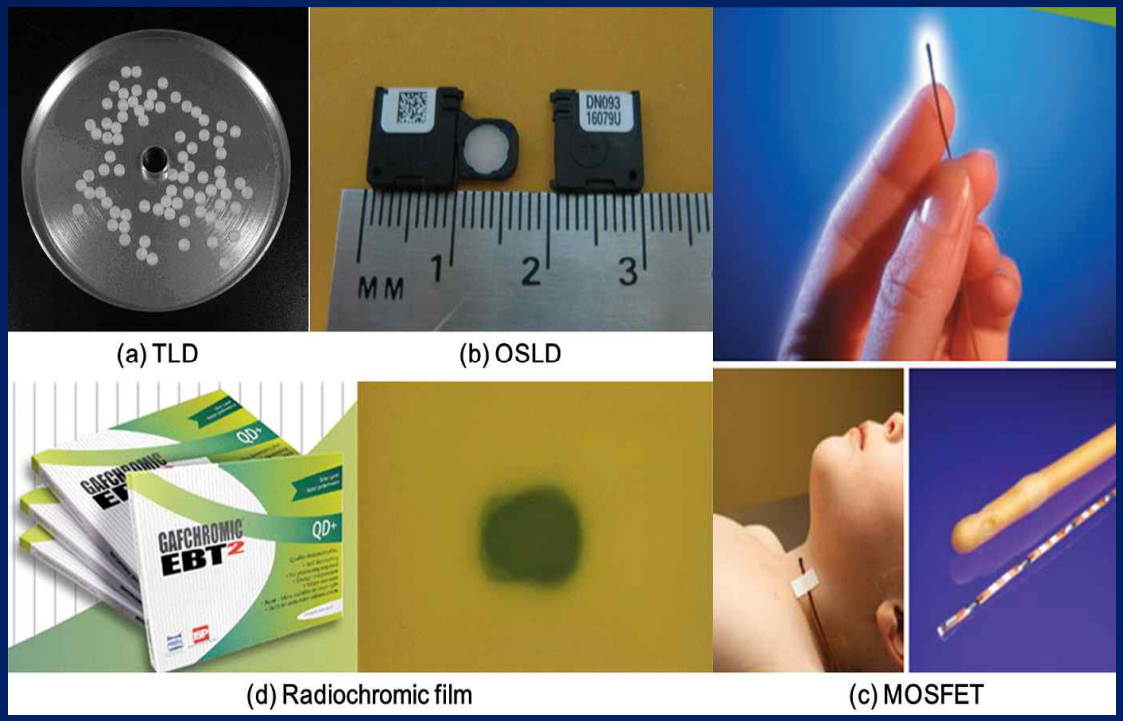
- VMAT plans for H&N cancer (nasal cavity)
  - Prescription of 67.5 Gy (daily 2.25 Gy, 30 fractions)
  - About 30 Gy/cm dose gradient near eye lens (whole fractions)

Eye lens dose in radiotherapy (cont'd)



- Eye lens located in a superficial region of the body
  - Dose calculation in this region is inaccurate
  - Calculated dose with TPS at a 3 mm depth could result in up to 30% difference from the measurement (Akino et al. Evaluation of superficial dosimetry between treatment planning system and measurement for several breast cancer treatment techniques. Med Phys. 2013;40(1):011714)
- Small volume of eye lens
  - About 0.1 – 0.2 cm^3
  - Large calculation grid in TPS could result in inaccurate calculation of dose to eye lens

In vivo dosimetry for eye lens

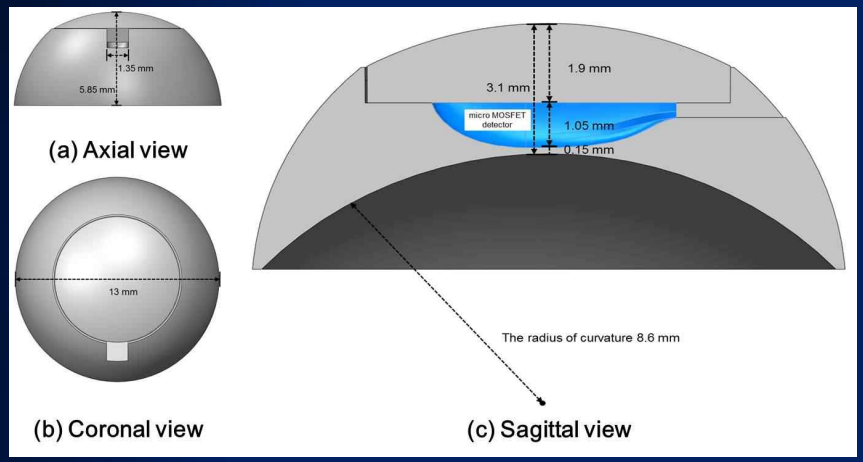


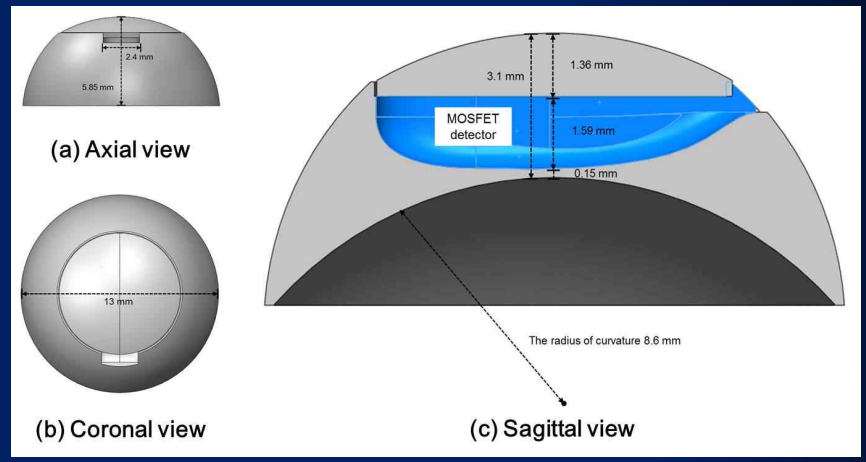
- Inaccurate dose calculation to eye lens → direct measurement, in vivo dosimetry
- Small dosimeter
  - Should not interrupt treatment beam
  - TLD, OSLD, MOSFET, Radiochromic film and so on
- Characterization of dosimeter should be verified before in vivo dosimetry
  - Dose linearity, dose-rate dependency, angular dependency and so on

In vivo dosimetry for eye lens (cont'd)

- In the clinic, generally performed on the surface of the eyelid
  - Steep dose gradient in the superficial region
  - No consideration of eye movement
- A Dosimeter with optimal contact with the eye is required
  - Contact lens-shaped dosimeter

Contact lens shaped applicator





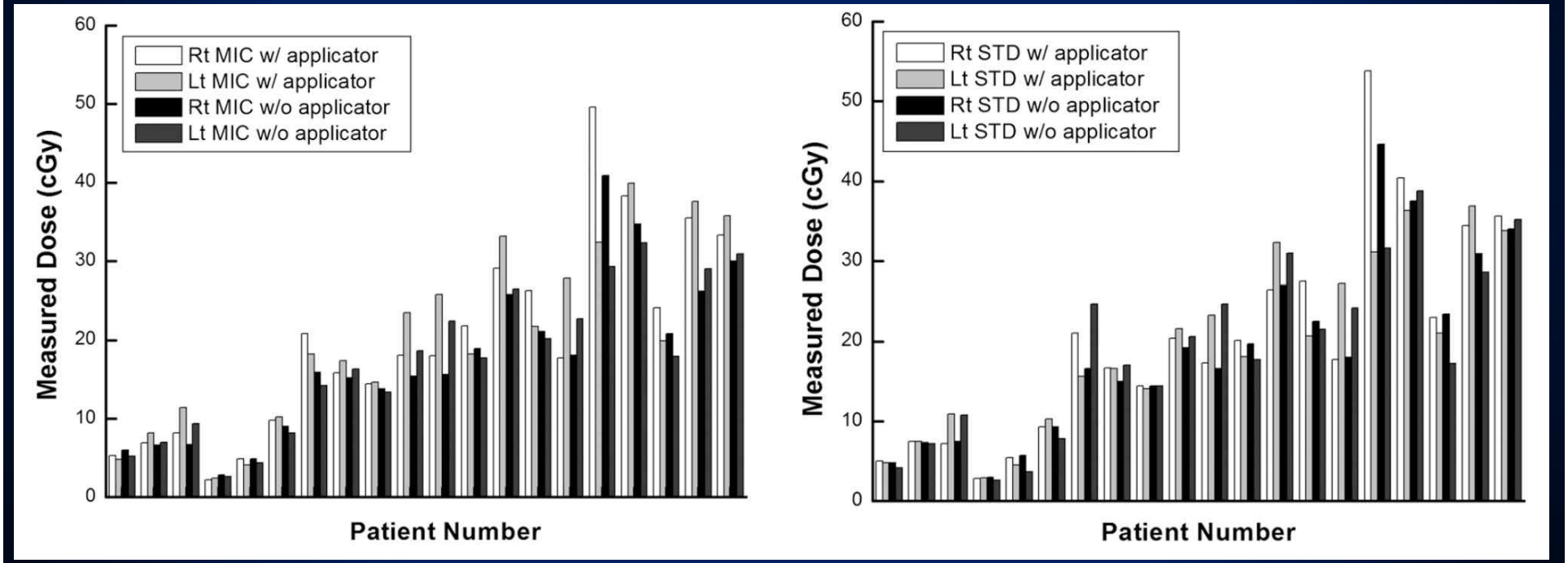
- Acrylic applicator in the shape of contact lens with a hole for the insertion of MOSFET dosimeter

Performance test

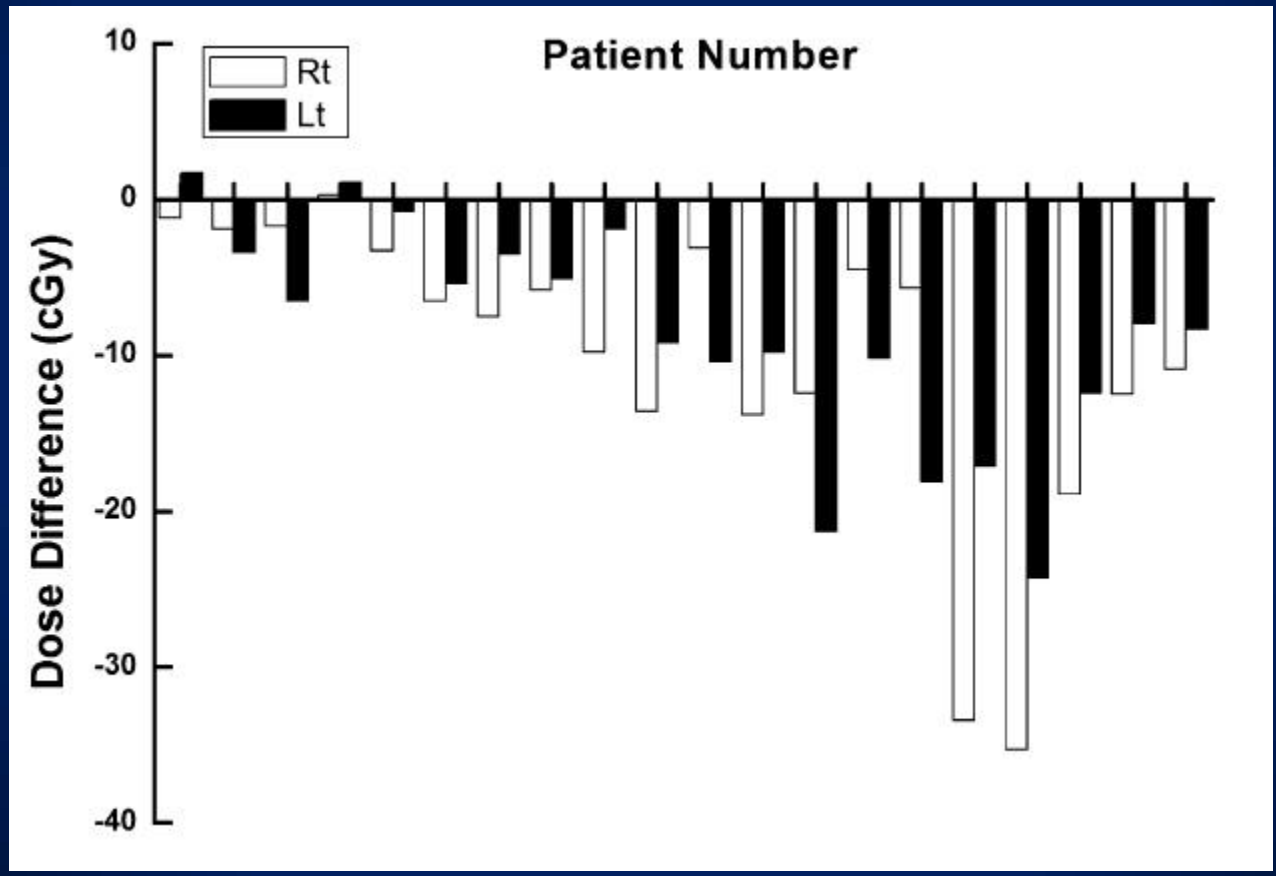
(a) Lens applicator (b) Lens applicator with MOSFET

- Anthropomorphic phantom (model 702 phantom, CIRS, Norfolk, VA)
- 20 VMAT plans
  - 10 VMAT plans for brain tumor
  - 10 VMAT plans for H&N cancer
- Lens dose were in the range of 0.5 – 17 Gy
- 2 arcs and 6 MV photon beam were used
- Differences between calculation and measurement without vs. with lens applicator

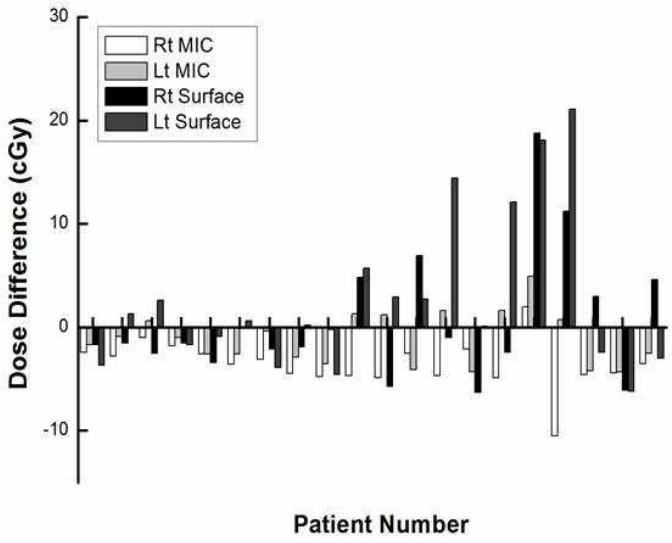
Measured dose



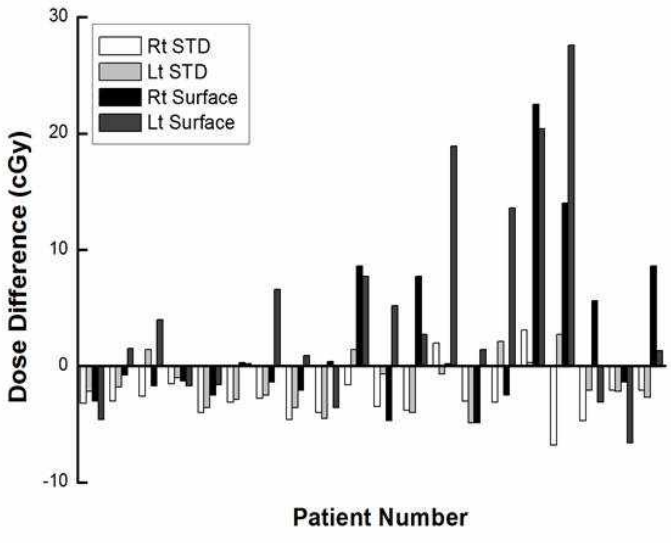
Measured on the eyelid vs. calculated lens dose



Measured vs. calculated at the same point



(a) MIC MOSFET



(b) STD MOSFET

Results

Analysis	Lens applicator	Surface	*p*	Lens applicator	Surface	*p*
	MIC			STD		
Average difference (cGy)	3.1 ± 1.8	4.8 ± 5.2	0.024	2.8 ± 1.3	5.7 ± 6.5	0.004
Maximum difference (cGy)	10.5	21.1		6.8	27.6	
Average difference (%)	16.8 ± 10.4	35.9 ± 41.5	0.003	16.6 ± 10.9	42.9 ± 52.2	0.002
Maximum difference (%)	46	188.4		44.4	246.4	
Number of cases over 20% difference	15	21		13	22	
Number of cases over 30% difference	5	14		5	18	
Number of cases over 40% difference	1	11		2	11	
Number of cases over 50% difference	0	6		0	11	

Summary

- We can calculate dose to eye lens, however, we cannot rely on the results of this calculation
  - Superficial location of eye lens
  - High dose gradient near eye lens
  - Patient setup error or eye movement during RT
- If needed, in vivo measurements can be performed to verify dose to eye lens
  - In vivo dosimeter characteristics should be verified before measurement
  - In vivo dosimeter should not interrupt treatment beam
  - Due to steep dose gradient in superficial region, in vivo dosimeter should be located as close as possible to eye lens
  - Eye movement can result in differences between measured and actual delivered dose to eye lens
- Contact lens shaped dosimeter could increase reliability of in vivo measurement for eye lens

Thank you for your attention