

State of Plaque Brachytherapy for Treatment of Ocular Lesions

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Purpose

- What is plaque therapy?
- Discuss locations and types of lesions.
- Review history of plaque brachytherapy.
- Describe a typical workflow.
- Discuss variations between institutions.
- Review recent developments.

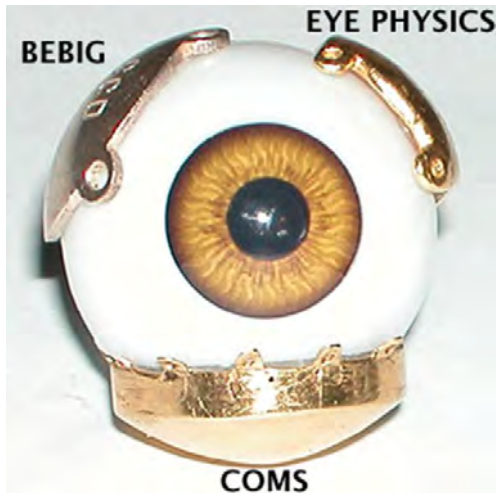
Plaque Therapy

- Used in the treatment of ocular lesions.
- Plaques loaded with radioactive seeds are surgically placed in close proximity to the tumor.
- The sources rapid dose fall-off is used to deliver a high tumor dose while sparing the retina.

Plaque Types



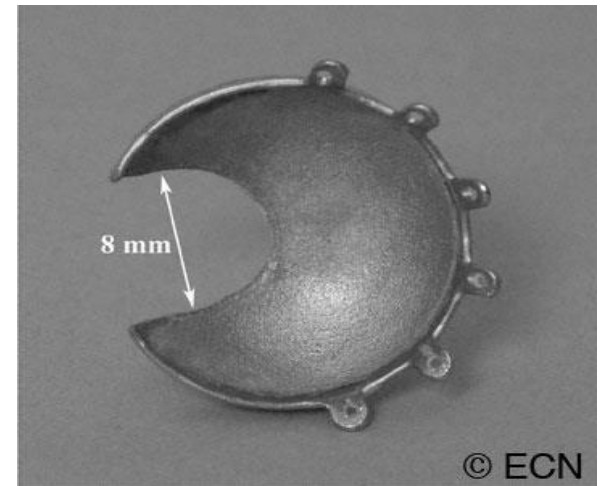
Source: www.bebig.com



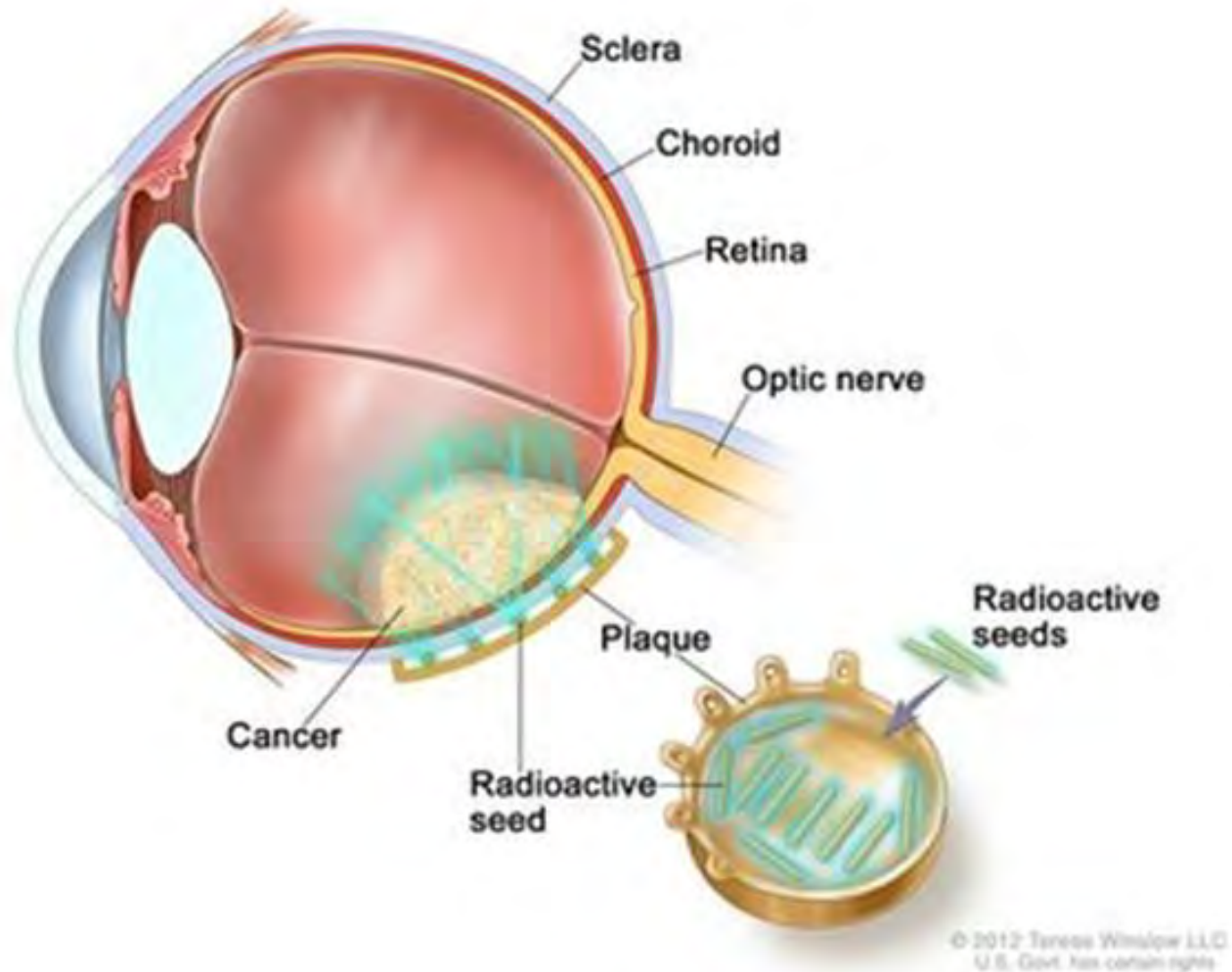
Source: www.eyephysics.com



Source: www.eyecancer.com



Plaque Sutured Over Tumor

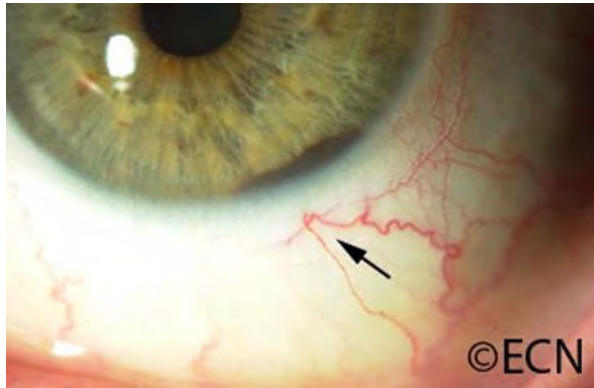


Common Lesions: Choroidal Melanoma

- Annually ~2500 cases of the following in the US.
- Subfoveal, Juxtapapillary/Circumpapillary

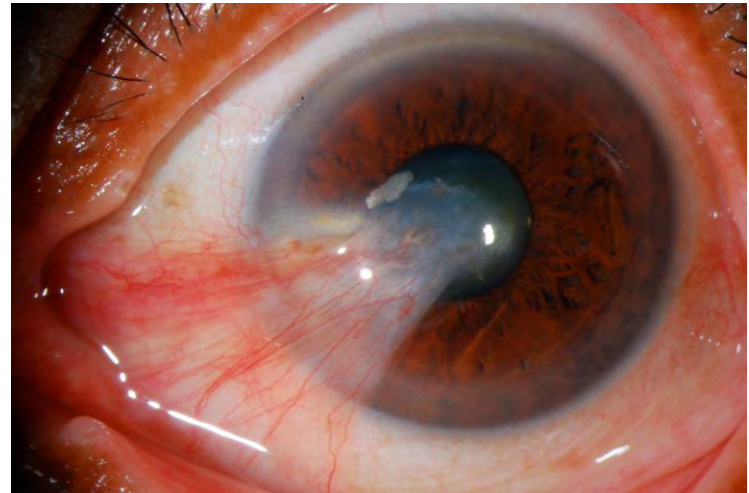


Common Lesions: Iris & Ciliary Body Melanomas



Less - Common Lesions

- Other lesions treated with plaques:
 - Hemangiomas
 - Retinoblastoma
 - Exudative Macular Degeneration
 - Pterygium



Pterygium Lesion

Risk Factors

- Ocular melanomas are more prevalent in people with light eyes (green & blue).
- There is a higher overall risk for Australians due to hole in the o-zone.
- Wear sunglasses.

History

1930: Choroidal Melanoma treated with radon.

- Interest grew with preservation of vision.
- A variety of procedures, Isotopes, and plaque designs were developed.
 - I-125, Pd-103, Ru-106
 - Cs-131, Ir-192, Au-198, Co-60, Sr-90

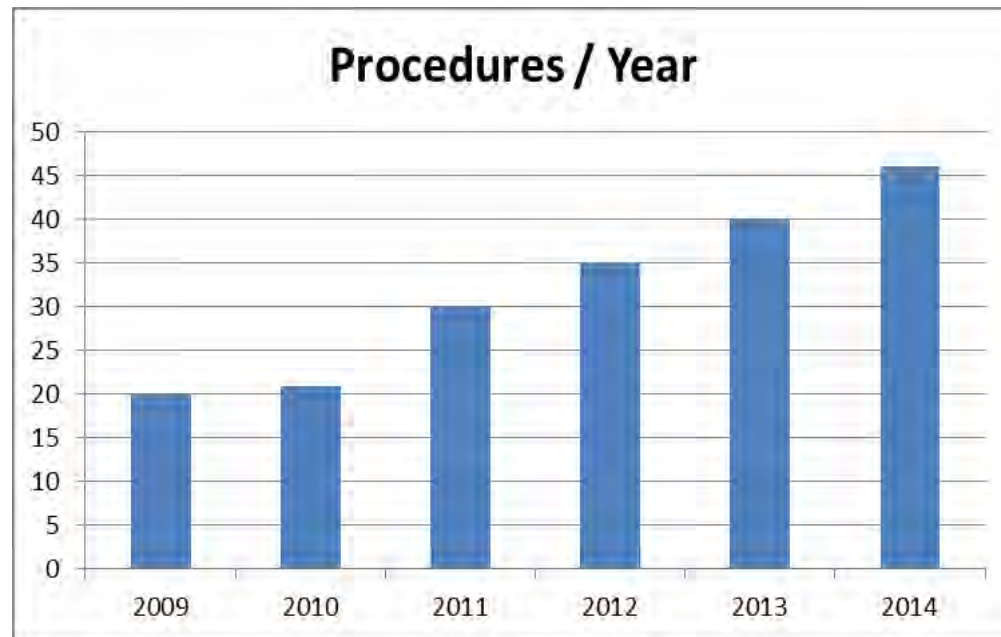
History

1985: Collaborative Ocular Melanoma Study (COMS)

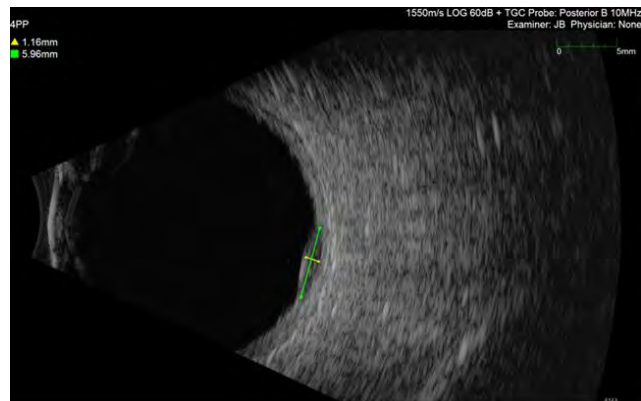
- Objective: standardization for comparison
- COMS created as a multi-institutional trial tasked with comparing plaque therapy to enucleation.
- Defined which tumors could be treated and over what period of time.
 - 2.5 to 10 mm in height and no greater than 16 mm diameter.
 - Tumor height verified accurately with ultrasound.
 - Standardized dosimetric considerations, such as prescription point.
 - Candidate requirements:
 - 21 or older
 - primary melanoma in only one eye with no history of metastatic disease.

Plaque Program at OHSU

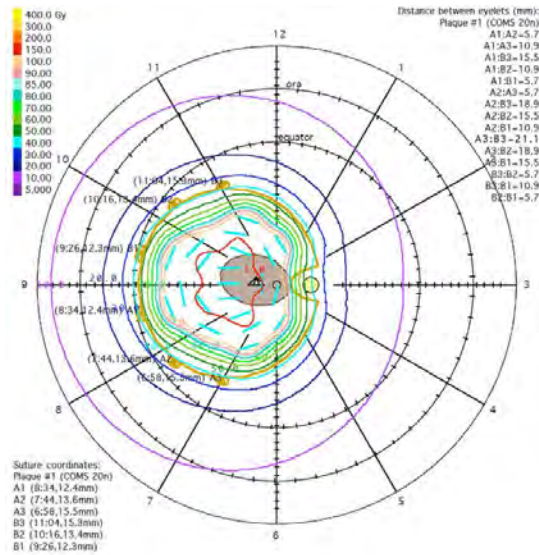
- Program has been active for over 30 years.
- Number of cases per year has been rising.
- Currently using I-125.



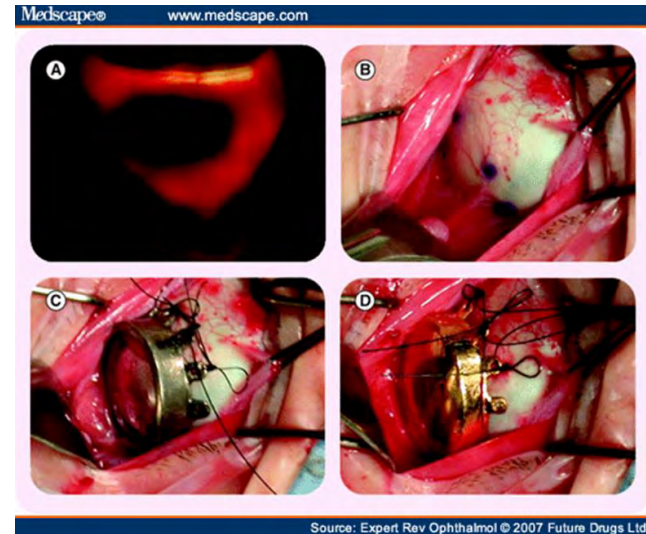
General Workflow



1. Consult & Simulation



2. Planning



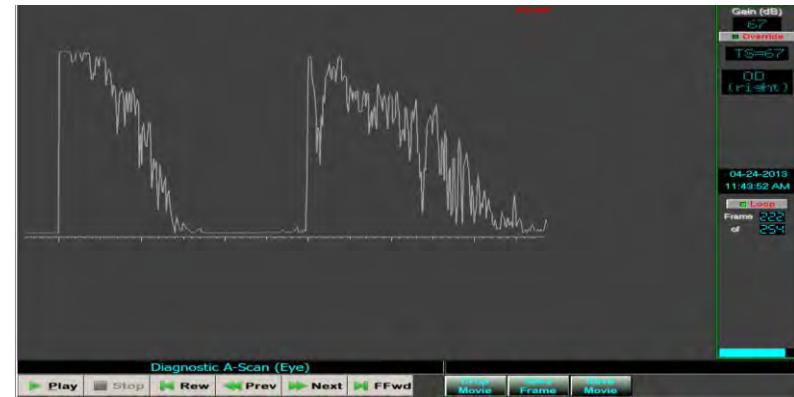
3. Localization

1. Consult & Simulation

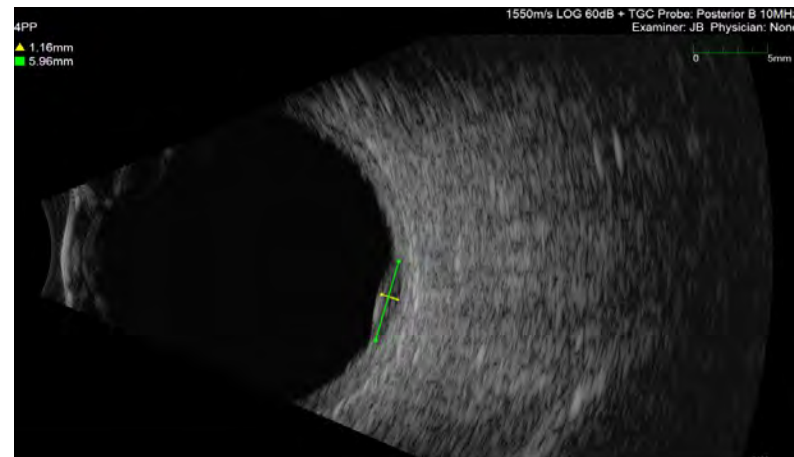
- Ophthalmology: Measure tumor dimensions



Wide-angle color fundus image collage.

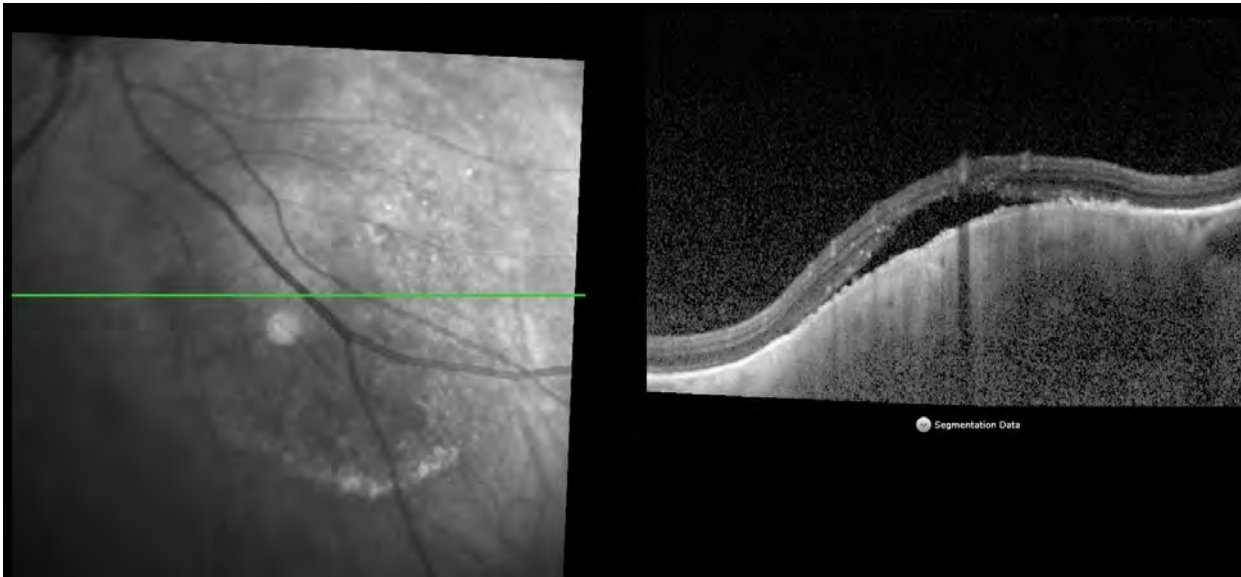


A-mode & B-mode Ultrasound

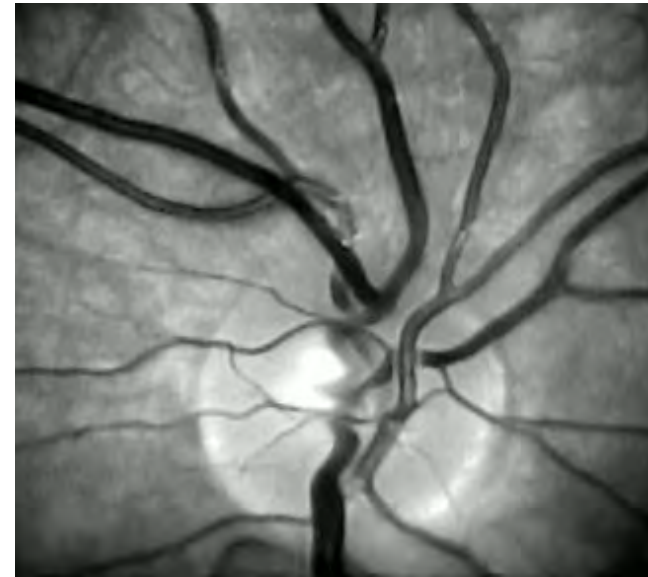


1. Consult & Simulation

- There is no shortage of imaging modalities!



Optical Coherence Tomography



Contrast Angio

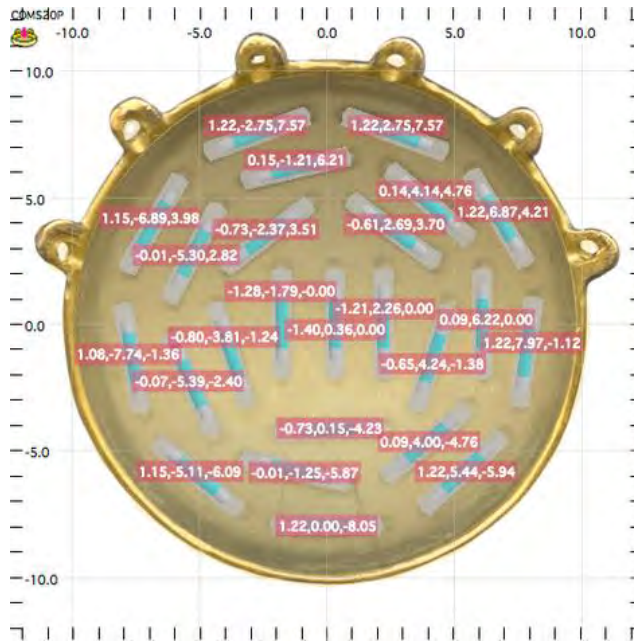
1. Consult & Simulation

- Radiation Oncology:
 - The physician will discuss radiation safety, treatment side effects, and expected outcome with the patient.
 - Discuss margins with physicist.
 - Typical margins are 2 – 3 mm.
 - Prescribe 85 Gy to a point.



2. Planning - Inputs

- Knowledge of seed coordinates allows the TG-43 formalism to be applied.



Seed Coordinates for a
COMS 20 mm Plaque
Mel Astrahan / plaquephysics.com

Basic Plan Inputs

Tumor Dimensions

Prescription Pt. Coordinate

Source Locations

Prescription Dose

Treatment Date & Times

Tumor Location on Orbit?

Special Factors?

2. Planning - TG-43 Formalism

$$\dot{D}(r, \theta) = S_K \cdot \Lambda \cdot \frac{G_L(r, \theta)}{G_L(r_0, \theta_0)} \cdot g_L(r) \cdot F(r, \theta)$$

- Source Strength
 - Air Kerma Strength (S_K)
 - For I-125: 1 mCi = 1.27 U
- Source Type
 - Dose Rate Constant (Λ)
 - Seed Specific: 0.981 cGy/h/U
- Location factors

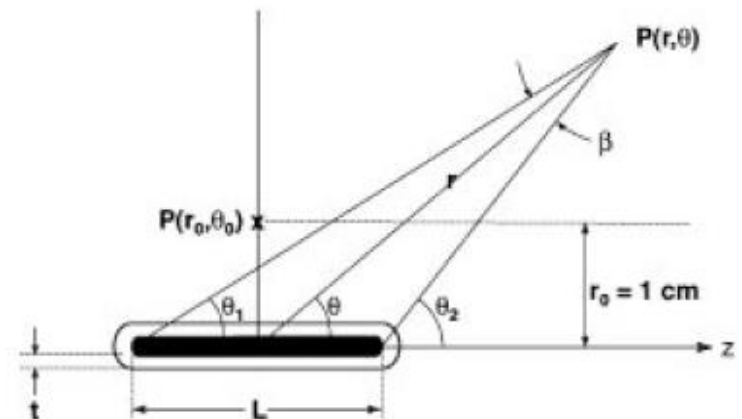
2. Planning – Location Factors

- Geometry Function
- Radial Dose Function
 - Fall-off from scatter and attenuation.
- Anisotropy Function
 - Source self-attenuation

$$G_P(r, \theta) = r^{-2}$$

$$G_L(r, \theta) = \frac{\beta}{Lr \sin \theta} \text{ if } \theta \neq 0^\circ$$

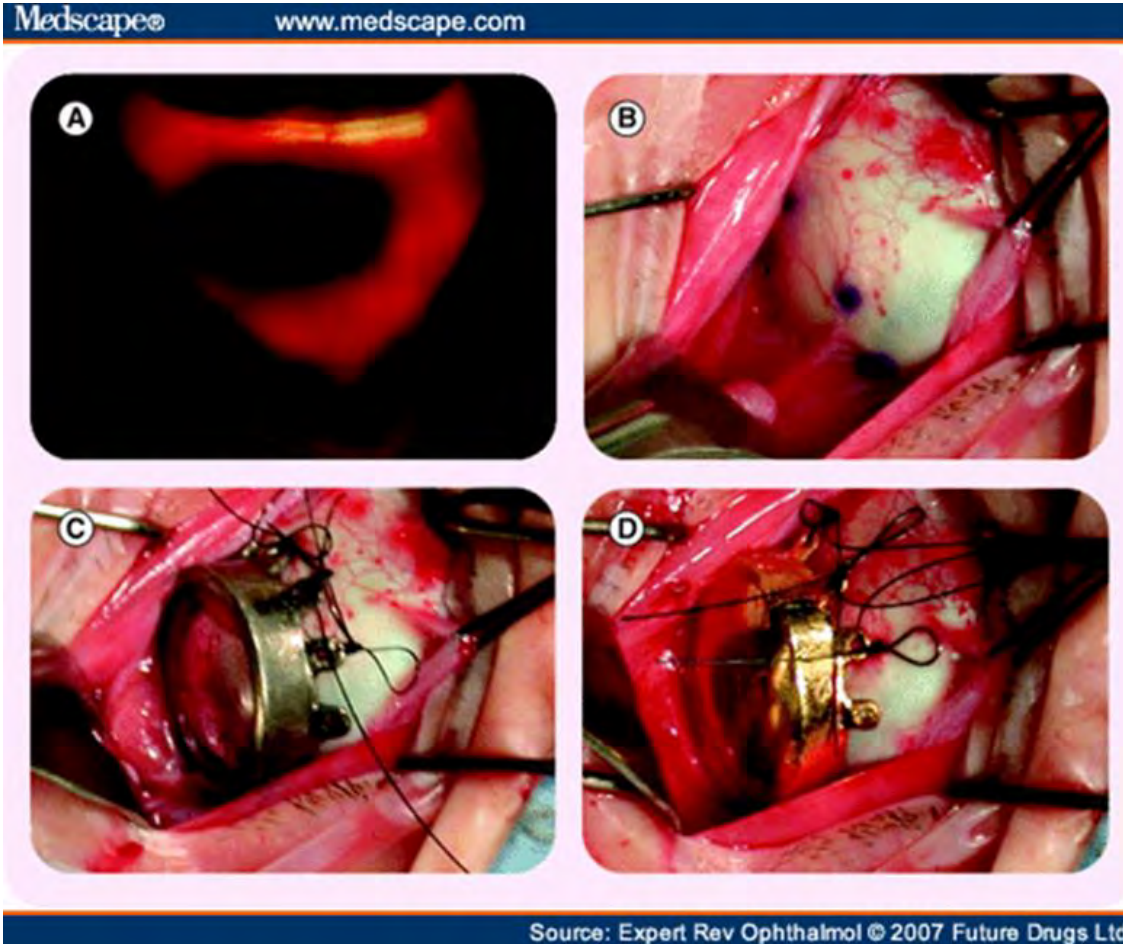
$$G_L(r, \theta) = (r^2 - L^2 / 4)^{-1} \text{ if } \theta = 0^\circ$$



2. Planning - Verification

- An independent check and calc is needed to verify the plan and primary calculation.
 - Should be perform by independent physicist.
 - Verifying a plan requires two of the following:
 - Excel/Matlab Handcalc
 - RadCalc
 - Brachyvision
 - Pinnacle
 - Plaque Simulator
 - Nomogram

3. Localization



Transorbital
Illumination

Scleral
Marker

Suture
Placement

Plaque
Placement

Source: Expert Rev Ophthalmol © 2007 Future Drugs Ltd

Method used at Cleveland Clinic

3. Localization - Verification

- OHSU does not locate suture positions prior to plaque placement.
 - Illumination / Visualization still used.
 - Plaque placement is verified by an ophthalmic echographer who uses a 10 MHz probe in B-mode.

Concerns

- What are reasonable prescription points for a given tumor?
- For a given tumor different seed activities would be ordered simply because of the calculation system being used.

Prescription Depth

- Some centers prescribe to tumor apex.
- Some use tumor apex + margin.
- Some use COMS prescription point.
- OHSU uses a tiered system:

Tumor Depth (mm)	Prescription Point (mm)
< 2.5	3.0 inside sclera
2.5 – 2.9	3.5 inside sclera
3.0 – 3.4	4.0 inside sclera
3.5 – 3.9	4.5 inside sclera
4.0 – 5.0	5.0 inside sclera
> 5.0	Apex of Tumor

Depth is Important!

Plaque Simulator Treatment Plan

Tumor 1 TAX (mm)	Avg. dose rate (cGy/hr)	Total Dose (Gy)
0.00	267.1	269.4
1.00	200.6	202.4
2.00	157.3	158.7
3.00	125.9	127.0
4.00	102.0	102.9
5.00	83.39	84.11
6.00	68.71	69.31
7.00	57.08	57.57
8.00	47.78	48.20
9.00	40.30	40.64
10.00	34.24	34.53
Critical Site	Avg. dose rate (cGy/hr)	Total Dose (Gy)

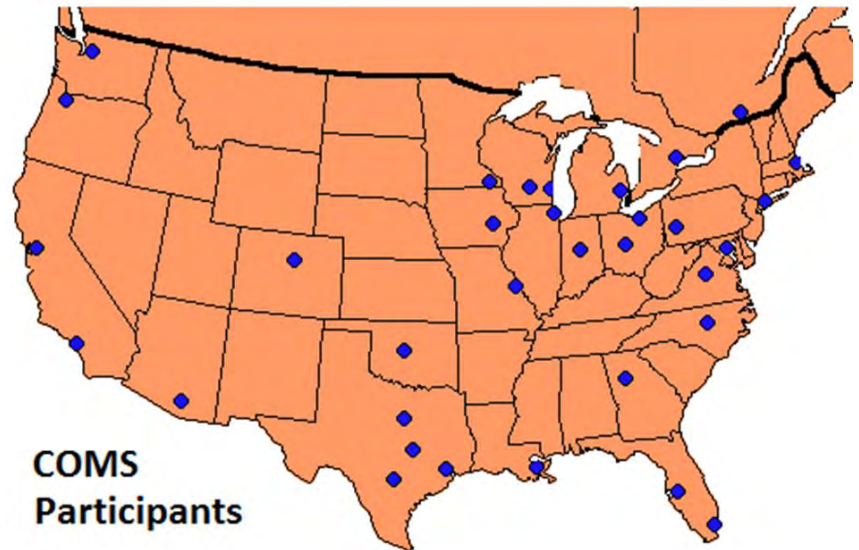
Planning Factors

There are many variables a system chooses to include or disregard in the calculation.

- Silastic Attenuation (12-15%)
- Point vs. Line Source Model
- Orbit Size
- Scleral Thickness
- Anterior Chamber Thickness
- Tissue Density
- Backscatter & Collimation

What variation exists in the US?

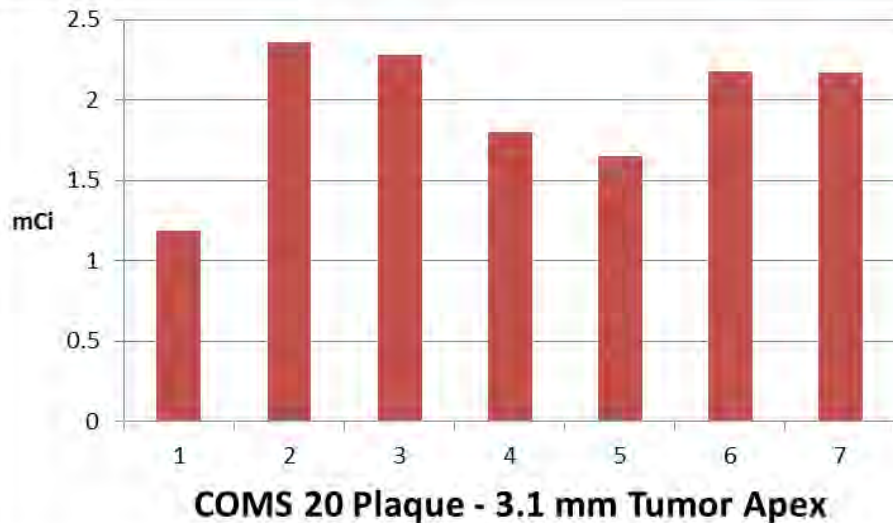
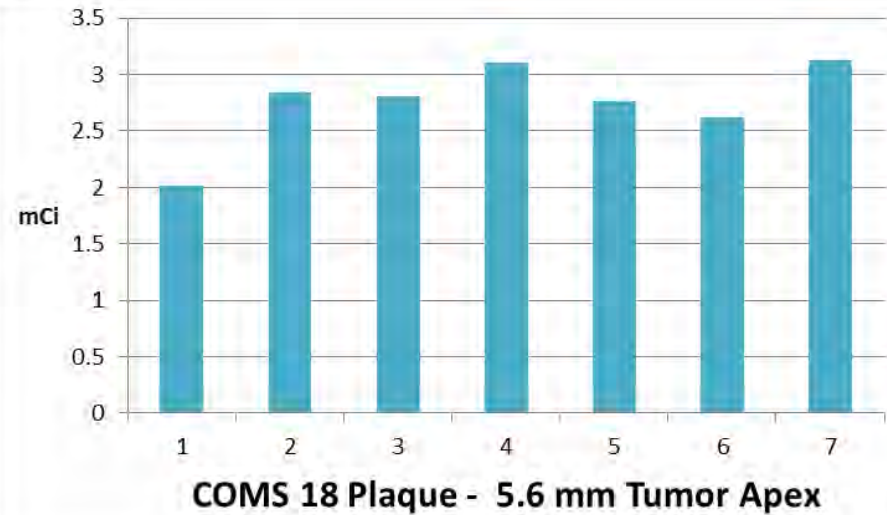
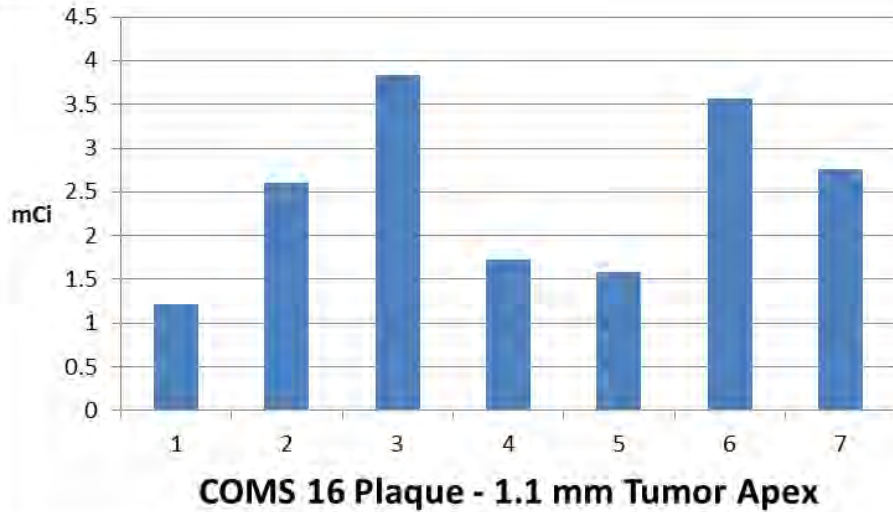
- A survey was designed to evaluate inter-institution consistency.
- Additional information was obtained by telephone and site visits.
- Many respondents had previously taken part in the COMS study.



Survey Question

- What seed activity would be ordered to deliver 85 Gy to your usual prescription point for the following parameters?
 - What would the tumor apex dose be under these conditions?
 - 100 hour implant time for a fully loaded plaque with an insertion time of 9:00 AM on March 10 and removal at 1:00 PM on March 14.

Survey Results



Shallow Tumors are more affected by prescription point depth.

Considerations

- Survey investigated the simplest cases.
- Actual implant durations vary from 72–168 hrs
- ABS – Ophthalmic Oncology Task Force (2014)
 - Offers guidance on Dose Prescription.
 - Following their advice to prescribe to apex and cover tumor would be a step in the right direction for standardization.
- Survey only focused on I-125
 - Pd-103 has arguable advantages.

Recent & Upcoming Literature

- TG-129: “Dosimetry of I-125 and Pd-103 COMS eye plaques for intraocular tumors: Report of Task Group 129 by the AAPM and ABS”
- ABS-OOTF: “The American Brachytherapy Society consensus guidelines for plaque brachytherapy of uveal melanoma and retinoblastoma” (Ophthalmic Oncology Task Force)
 - 47 Centers worldwide took part in their study & recommendations.
- TG-221: “AAPM Recommendations for Ocular Brachytherapy”
 - Expected publication in December of 2014.

Future Directions

- Outcome Databases
 - Wills Eye and Cleveland Clinic projects underway.
- Intraocular Silicone Oil
 - Can reduce retina dose by ~55% in some cases.
- Consideration of Pd-103
 - Majority of centers still use I-125.
 - Pd-103 has faster dose fall-off (higher gradients).
- Collaboration and standardization.

Summary

- Plaque therapy has been used to effectively treat ocular melanomas for many years.
- Opportunities exist to maintain tumor control while reducing dose to critical structures and improve preservation of vision.
- Development of standardization methods is needed.

Special Thanks

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