Dosimetric Impact of Silastic Insert Thickness in COMS Eye Plaque for I-125 Brachytherapy

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Background- Ocular Melanoma

- 1400 cases of ocular melanoma are diagnosed annually
- Treatment options:
  - Radiation Therapy (>75%)
    - Eye plaque
    - Proton therapy
    - Gamma Knife
  - Enucleation (<25%)

Aronow et al. 2018
Background- COMS

- 1985 Collaborative Ocular Melanoma Study (COMS) was formed to evaluate two methods of tumor control and survival:
  1) 20 Gy external beam therapy prior to enucleation vs. no radiation prior to enucleation
     • *Radiation did not improve survival*
  2) Enucleation compared to I-125 eye plaque therapy
     • *No difference in survival!*

- COMS findings standardized plaque brachytherapy
Background- COMS Plaque

A. Iodine-125 seeds
   - Mean photon energy: 28 keV
   - $T_{1/2}$: 59.4 days

B. Silastic seed carrier insert
   (Dow Corning Corp., Midland, MI)
   - MDX-4210, a medical grade elastomer
   - Places seed 1mm from Sclera

C. Gold-alloy backing
   (Trachsel Dental Studio, Rochester, MN)
   - 10 – 22mm
Problem: Inconsistent Silastic Thickness

- The COMS Silastic insert is described as 2mm thick, placing source 1mm from Sclera
- Inserts appear to be manufactured with varying thickness
  - Especially for large, 22mm plaques
  - Added thickness increases distance between source and prescription point
  - How does this effect dose to the tumor? Normal eye structures?

Chiu-Tsao et al., Med Phys 2012
Methods

1) Measure thickness of 13 inserts
   - All 22mm COMS plaque
   - Digital Caliper used to measure the lip height, and determine thickness

2) Dose Calculations using BrachyVision (TG-43)
   - Vary distance from source to prescription point based on ranging Silastic thickness (2, 2.5 or 3mm)
   - Account for different tumor apex heights (5, 7, 10mm)
     • Adjust activity to deliver 85 Gy to tumor apex (as recommended by American Brachytherapy Society)
   - Calculate doses to critical structures
     • tumor apex, sclera, lens, macula, opposite retina, and optic disk
Results: Measured Silastic Thickness

- Based on measurements, inserts were grouped into standard, medium, and thick.
- Mean thicknesses were rounded to the nearest half millimeter (2, 2.5, 3mm).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>n</th>
<th>Mean (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>5</td>
<td>1.93 → 2</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
<td>2.36 → 2.5</td>
</tr>
<tr>
<td>Thick</td>
<td>6</td>
<td>3.22 → 3</td>
</tr>
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</table>
Results: Dose Calculations

- Percent prescription dose (%PD), relative to 85 Gy at the tumor apex, is determined for critical eye structures based on:
  1) Silastic Thickness
  2) Tumor Size

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<td>5mm 7mm 10mm</td>
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<tr>
<td>Tumor Apex</td>
<td>100.3 100.0  99.8</td>
<td>92.6 92.7  92.9</td>
<td>85.8 86.0  86.6</td>
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<tr>
<td>Sclera</td>
<td>268.7 364.6  568.1</td>
<td>232.3 315.1  491.1</td>
<td>204.9 277.9  433.1</td>
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<td>Lens Center</td>
<td>27.6 37.5  58.4</td>
<td>25.9 35.1  54.8</td>
<td>24.3 33.0  51.4</td>
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<td>Macula</td>
<td>41.6 56.4  87.9</td>
<td>38.7 52.5  81.8</td>
<td>36.1 48.9  76.3</td>
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<tr>
<td>Opposite Retina</td>
<td>10.7 14.5  22.6</td>
<td>10.1 13.8  21.4</td>
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<td>Optic Disk</td>
<td>52.1 70.6  110.1</td>
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<td>44.4 60.2  93.9</td>
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Results: Dose Calculations (cont.)

- As Silastic thickness increases, %PD decreased
- As tumor apex increases, %PD to normal eye structures increased, as expected

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Results: Dose Calculations (cont.)

[Bar chart showing % Prescription Dose for different eye structures and thicknesses.]
Results: Dose Calculations (cont.)

- As Silastic thickness increases, %PD decreased
Discussion

• Unaccounted for, thick silastic inserts will add distance from source to tumor apex
  – ~7% loss of prescription dose for each additional 0.5mm of Silastic thickness

• Even larger effects would be expected after heterogeneity corrections
  – TPS measurements consider only water ($Z_{\text{eff}}=7.4$), not Silastic ($Z_{\text{eff}}=11$)
  – Higher electron density → Silastic is more attenuating

• Normal eye structures saw reduction in dose
  – Distance is advantageous in this case
Conclusions

• As Silastic insert thickness increases, the tumor receives a lower dose than prescribed
• Recommendations:
  – Quality Assurance procedures should be developed to verify Silastic insert thickness
  – Communicate with vendor if Silastic molds are not in agreement with standards
Acknowledgments

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References