Plaque Size and Dose in I-125 Eye Plaque Brachytherapy

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Purpose/Objectives

Uveal melanoma is the most common primary intraocular malignancy in adults. Eye sparing treatment with brachytherapy yields excellent local control but often results in significant vision loss and toxicity. Though the pathology underlying these side effects is incompletely understood, it is generally agreed that dose correlates with toxicity. Associations between normal tissue dose and toxicity include the lens and cataracts, the opposite retina and neovascularization and glaucoma, the macula and maculopathy and visual acuity, and the optic disc and optic neuropathy and visual acuity. As accuracy in modeling doses to these structures improves, it is possible to better study how they are influenced by changes in treatment technique.

Our institute often uses COMS-style plaques that are larger than the COMS minimum due to surgical preference. This study retrospectively examines doses delivered to critical structures in patients treated with I-125 plaque brachytherapy. We compare our implanted doses versus doses calculated using the minimum plaque-size per COMS recommendations in order to determine if larger plaques increase the doses to relevant structures.

Materials and Methods

25 patients treated from 2013-2015 with plaques larger than the COMS minimum (2mm margin around the tumor) were analyzed. ***Eye Plaque Simulator Version *** software was used for planning, and standard COMS-style plaques were used in all cases. Plaques were loaded with uniform I-125 seeds to deliver 85Gy to the tumor apex or apex + margin for tumors <5mm thick. Planned duration of irradiation was 100 hours, but actual treatment duration was used for analysis. Plans for comparison were generated to deliver the same dose to the prescription point over the same time, but the plaque size was reduced to COMS minimum. Point doses to the tumor apex, lens, optic disc, macula, opposite retina, and sclera were calculated. D50 for the lens, optic disc, macula, and base of tumor + 2mm margin were measured. Paired t-tests were used for analysis.

Results

Table 1. Plaque and Tumor Characteristics

<table>
<thead>
<tr>
<th>Number</th>
<th>Margin</th>
<th>Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral</td>
<td>11</td>
<td>Surgical</td>
<td>2.95-7.9mm</td>
</tr>
<tr>
<td>Central</td>
<td>7</td>
<td>COMS</td>
<td>2.85-3.3mm</td>
</tr>
<tr>
<td>Notch</td>
<td>7</td>
<td>Thickness</td>
<td>1.1-1.6mm</td>
</tr>
<tr>
<td>Temporal</td>
<td>15</td>
<td>Maximum Dimension</td>
<td>6.2-15.9mm</td>
</tr>
<tr>
<td>Nasal</td>
<td>10</td>
<td>Treatment Time</td>
<td>98.58-101.63hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seed Strength</td>
<td>1.79-3.07mCi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surgical</td>
<td>1.79-3.07mCi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>COMS</td>
<td>1.80-5.13mCi</td>
</tr>
</tbody>
</table>

Figure 1. Comparison of doses using surgical plaques vs. COMS plaques. Differences were statistically significant for the sclera (11.55% ± 13.97, p = 0.0002), opposite retina (-25.71% ± 17.6, p=0.0001), lens (-31.33% ± 18.84, p=0.0001), tumor apex (7.64% ± 9.8, p=0.0065), and D50 Tumor Base (15% ± 0.25, p=0.0099).

Figure 2. Comparison of doses to the macula and optic disc using surgical plaques vs. COMS plaques grouped into peripheral or central tumor location. A. For peripheral tumors, the optic disc and macula receive less dose with a COMS plaque (-23.48% ± 19.65, p = 0.041), but for central tumors treated with plaques without a notch, the macula receives more dose (16.32% ± 28.36, p = 0.026). No difference was seen with notch plaques. B. For peripheral tumors, the optic disc and macula D50s were less with a COMS plaque (-22.05% ± 19.6, p = 0.041), but for central tumors treated with plaques without a notch, the macula D50 was greater (12.21% ± 25.7, p = 0.024). No difference was seen with notch plaques.

Figure 3. Eyes grouped by lens D50 for surgical and COMS plaques. The larger, surgically selected, plaques tended to deliver a higher dose to 50% of the lens than smaller COMS plaques. This is evidenced by the increased number of eyes with lens D50 >10Gy for surgically selected plaques.

Figure 4. Tumor:Macula (T:M) ratio is higher using COMS plaques for peripheral tumors (p = 0.0124) but lower for central tumors without notch plaques (p = 0.0012). T:D has been suggested to be predictive of maculopathy. B. Tumor:Optic disc (T:D) ratio is higher using COMS plaques for peripheral tumors (p = 0.0081). No difference was seen for central plaques. T:D has been suggested to be predictive of optic neuropathy.

Figure 5. Comparison of doses to the macula and optic disc using surgical plaques vs. COMS plaques grouped into temporal or nasal tumor location. There is no difference in dose between the 2 plaque sizes when tumors are grouped into temporal and nasal locations except for a decrease in the macula D50 (-13.81% ± 15.35, p = 0.018) for nasal tumors using COMS plaques.

Conclusions

- For all lesions, smaller plaques delivered a:
  - Higher dose to the tumor apex
  - Higher dose to the sclera
  - Lower dose to the opposite retina
  - Lower dose to the lens

- For peripheral lesions, smaller plaques delivered a:
  - Lower dose to the optic disc
  - Lower dose to the macula

- For central lesions, smaller non-notched plaques delivered a:
  - Higher dose to the optic disc
  - Higher dose to the macula

- For central lesions, no difference was seen using notch plaques

- Peripheral/central location was more influential than temporal/nasal location for guiding plaque size choice

References

2. Wen, Oliver, and McCannel. Eye. 2003 Vol. 23, 1254-1268