Objective: To describe clinical experience with palladium 103 (103Pd) ophthalmic plaque radiotherapy for choroidal hemangioma.

Methods: One course of 103Pd ophthalmic plaque radiotherapy was used in each of 5 patients with circumscribed choroidal hemangioma who had progressive loss of vision due to subretinal exudation. A mean apex dose of 2900 cGy (2900 rad) was delivered. Functional tests of outcome included best-corrected visual acuity. Anatomic results included changes in tumor height and subretinal fluid documented by ophthalmoscopy, fluorescein angiography, and ultrasonography.

Results: All patients had complete resolution of subretinal fluid with reattachment of the retina. All tumors decreased in height (mean, 50%) after treatment. Three patients (60%) demonstrated improvement in visual acuity at the last follow-up, and in 1 patient vision remained stable with resolution of metamorphopsia. Twenty-four months after treatment, 1 patient whose visual acuity had recovered from 20/160 to 20/32 had a loss of vision to 20/160 because of radiation maculopathy. For all patients, a mean visual acuity improvement of 2 lines was documented (95% confidence interval, 0.23-0.88). Mean follow-up was 18.6 months (range, 6-29 months).

Conclusions: A single 103Pd plaque radiation treatment was effective in decreasing tumor height, eliminating subretinal fluid, and improving visual acuity in patients with symptomatic circumscribed choroidal hemangiomas.


Author Affiliations:
Departments of Ophthalmology, New York Eye Cancer Center (Drs Aizman and Finger), New York Eye and Ear Infirmary (Drs Shabto and Berson), and New York University School of Medicine (Drs Aizman and Finger), and Department of Radiation Oncology, St Vincent’s Comprehensive Cancer Center (Drs Szechter and Berson), New York.
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tion of subretinal fluid in all patients and suggested that stereotactic therapy be targeted to small and posteriorly located circumscribed choroidal hemangiomas.14

In 1989, palladium 103 (103Pd) seeds became available for brachytherapy.21 Comparative studies have shown that when equivalent target doses were prescribed, the use of 103Pd resulted in an increased dose within the targeted zone (tumor) and less radiation to most normal ocular tissues compared with 125I.22 An 11-year study of 103Pd plaque radiotherapy for choroidal melanoma found better visual function outcomes compared with the results from centers using 125I.23

Herein are reported what we believe to be the first visual and anatomic results of a series of patients with symptomatic choroidal hemangiomas treated with 103Pd ophthalmic plaque radiotherapy.

**METHODS**

**PATIENT SELECTION**

A prospective, nonrandomized clinical study was conducted in 5 consecutive patients with previously untreated and symptomatic circumscribed choroidal hemangiomas. The diagnosis was made by clinical ophthalmoscopic, fluorescein angiographic, and ultrasonographic features. Each patient participated in a detailed discussion of the risks and benefits of various therapeutic modalities. All patients signed a statement of informed consent. Institutional review board approval was not considered necessary because of the established use of radiation therapy for choroidal hemangiomas.

**DIAGNOSIS**

Clinical history included the patient’s age, sex, and medical history. Ophthalmic evaluations included a best-corrected visual acuity and pupillary, oculomotor, and slitlamp examinations. Goldmann tonometry was used to measure intraocular pressure. The basal dimensions of the tumors were determined by ophthalmoscopy, fluorescein angiography, transillumination, and B-scan ultrasonography. A-scan ultrasonography was used to measure the height of the tumor and internal reflectivity. B-scan ultrasonography was typically used to determine tumor location and shape and evidence of retinal detachments. Fluorescein angiography and fundus photography were used to evaluate and record patterns of tumor circulation, focal leakage, cystoid macular edema, and radiation retinopathy.

**STATISTICAL ANALYSIS**

The clinical data were analyzed with regard to improvement in visual acuity after treatment. The SPSS software package, version 11.01 (SPSS Inc, Chicago, Ill), was used for data analysis. The modified Wald test was used to calculate 95% confidence interval.

**PALLADIUM 103 OPHTHALMIC PLAQUE RADIOTHERAPY**

Palladium 103 seeds were available at strengths of up to 5 mCi (185 MBq) per seed (model 200; Theragenics Corp, Buford, Ga). The cylindrical titanium-encapsulated 103Pd seeds measured 0.8 mm in diameter and 4.5 mm in length. Seeds were affixed into standard COMS (Collaborative Ocular Melanoma Study)—type gold plaques (Trachsel Dental Studio Inc, Rochester, Minn) with a thin layer of medical-grade acrylic fixative. Because of low energy of x-rays from 103Pd, the 0.5-mm-thick plaque blocked more than 99% of photons directed to the sides and posterior to the plaque.22 Our methods of 103Pd plaque dosimetry have been described elsewhere.22,23

In this series, all patients received 1 radiation treatment. Eye plaques were sewn to the episclera to cover the base of the intraocular tumor, radiation was continuously delivered during 2 to 5 days, and the plaques were removed. The tumor apex served as the radiation prescription point. Treatment time and dose rate were calculated on the basis of the dimensions of the tumors and followed COMS guidelines, whereby the apex dose rate was kept between 50 and 125 cGy/h (50 and 125 rad/h). Similarly, a treatment margin of 2 mm was included around the edges of the tumor. The mean apex dose for the 5 patients who were treated with 103Pd was 2900 cGy (2900 rad) (Table 1).

### Table 1. Hemangioma Characteristics and Palladium 103 Treatment

<table>
<thead>
<tr>
<th>Patient No./Sex/Eye</th>
<th>Pretreatment Tumor Dimensions, mm</th>
<th>Plaque Diameter, mm</th>
<th>Apex Dose, cGy</th>
<th>Treatment Duration, d</th>
</tr>
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<tbody>
<tr>
<td>1/M/OD</td>
<td>8.0 9.0 3.6</td>
<td>14</td>
<td>2500</td>
<td>2</td>
</tr>
<tr>
<td>2/F/OD</td>
<td>6.6 5.5 4.0</td>
<td>12</td>
<td>4000</td>
<td>5</td>
</tr>
<tr>
<td>3/M/OS</td>
<td>9.0 9.0 2.8</td>
<td>14</td>
<td>2700</td>
<td>2</td>
</tr>
<tr>
<td>4/F/OS</td>
<td>7.0 9.0 3.4</td>
<td>12</td>
<td>3100</td>
<td>5</td>
</tr>
<tr>
<td>5/F/OD</td>
<td>8.0 8.0 2.5</td>
<td>12</td>
<td>2000</td>
<td>2</td>
</tr>
</tbody>
</table>

Conventional units: To convert apex dose to rad, multiply centigray by 1.

### Table 2. Results of Palladium 103 Treatment

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Tumor Height</th>
<th>Visual Acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretreatment</td>
<td>Final</td>
</tr>
<tr>
<td>1</td>
<td>3.6</td>
<td>0.7</td>
</tr>
<tr>
<td>2</td>
<td>4.0</td>
<td>3.4</td>
</tr>
<tr>
<td>3</td>
<td>2.8</td>
<td>2.1</td>
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<tr>
<td>4</td>
<td>3.4</td>
<td>1.3</td>
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<tr>
<td>5</td>
<td>2.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Mean</td>
<td>3.3</td>
<td>1.7</td>
</tr>
</tbody>
</table>

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Figure. Pretreatment (A, C, and E) and posttreatment (B, D, and F) optic disc photographs, fluorescein angiograms, and ultrasound scans in a patient with circumscribed choroidal hemangioma treated with palladium 103 ophthalmic plaque radiotherapy. A, Pretreatment photograph showing the orange choroidal hemangioma extending beneath the fovea before brachytherapy. B, Posttreatment photograph demonstrating flattening of the tumor with residual retinal pigment epithelial mottling 29 months after treatment. C, Fluorescein angiogram before treatment showing a coarse intratumoral vascular pattern extending to the fovea. D, Pattern of residual transmission defects within the targeted zone. E, Pretreatment 10-MHz B-scan ultrasound demonstrating the highly reflective choroidal tumor and retinal detachment. F, Most recent ultrasound, obtained 25 months after treatment, showing a flattened choroidal hemangioma with complete resolution of the exudative retinal detachment. The plus sign represents the measuring cursor for the ultrasound image; the scale is in centimeters (larger intervals).
Five patients with symptomatic circumscribed choroidal hemangiomas were treated by $^{103}$Pd brachytherapy. The mean age in this group was 55 years (range, 45-70 years). Follow-up was documented during a mean interval of 18.6 months (range, 6-29 months). The mean height of all tumors was 3.3 mm as measured by ultrasound (range, 2.5-4.0 mm) (Table 2). All tumors decreased in height (to a mean of 1.7 mm) (Figure). No tumor recurrence was noted.

All tumor-associated retinal detachments resolved within the reported follow-up period (Figure). Visual acuity improved in 4 (80%) of 5 patients after treatment, and 1 patient's visual acuity remained stable at 20/32 (with resolution of metamorphopsia). Twenty-four months after treatment, 1 patient whose visual acuity had recovered from 20/160 to 20/32 had a loss of vision to 20/160 because of radiation maculopathy. At the last follow-up, 3 patients (60%) retained their postoperative best-corrected visual acuity. For all patients, a mean visual acuity improvement of 2 lines was documented (95% confidence interval, 0.23-0.88) (Table 2). Compared with the results after other radiotherapy techniques, no new complications could be attributed to the use of $^{103}$Pd.

Circumscribed choroidal hemangioma is a vascular tumor that can cause permanent loss of vision by leakage of subretinal fluid, associated retinal detachment, and cystoid degeneration of the retina. Management becomes more problematic with large or anteriorly located tumors, lesions associated with extensive bullous retinal detachment, or tumors located in proximity to the optic nerve or fovea. Laser photocoagulation will typically reduce the exudative subretinal fluid, but recurrences are common and associated with vision loss. Recently, Schmidt-Erfurth et al., Madreperla, Robertson, and other researchers have reported on PDT in treatment of symptomatic circumscribed choroidal hemangiomas. On average, 2 PDT treatments were required to control exudation of subretinal fluid. Overall, 60 patients were treated and 51 had an improvement in visual acuity (mean, 3.3 lines) after PDT (Table 3). Tumors were noted to decrease from a mean pretreatment tumor height of 3.0 mm to 0.4 mm at the last follow-up measurement. It is important to note that problems associated with PDT for large vascular lesions have included focal overtreatment, leading to chorioretinal atrophy and resultant visual field defects. Photodynamic therapy is not practical for treatment of large or anteriorly located hemangiomas. Clearly, PDT relies on the visualization of the hemangioma to aim...
the sensitizing laser spot and to provide complete coverage of the lesion. Therefore, if a tumor is hidden beneath a large serous retinal detachment, treatment of the tumor by PDT becomes problematic. In contrast, ophthalmic plaque radiotherapy is performed throughout the sclera and therefore is not dependent on visualization of the tumor during treatment. Finally, unlike PDT, ophthalmic plaque brachytherapy requires 2 surgical procedures.

Several investigators reported favorable anatomic and visual results after external beam radiotherapy for choroidal hemangiomas (Table 4). They suggested that external beam radiotherapy could be a useful therapeutic option for symptomatic choroidal hemangiomas. However, when compared with plaque brachytherapy, external beam radiotherapy distributes radiation over a larger area, potentially increasing the risk of radiation-induced keratoconjunctivitis sicca, cataract, retinopathy, or optic neuropathy.

Recently, Kivela et al reported a series of 5 patients with symptomatic circumscribed choroidal hemangiomas treated with stereotactic radiotherapy. In their series, 1 patient lost 7 lines of best-corrected visual acuity at 26 months and 4 patients were within 2 lines at 20 months of follow-up. The relatively high cost of stereotactic radiotherapy must be considered in the current era of cost-effectiveness.

In 1966, Stallard introduced the first radioactive ophthalmic plaques (60Co). Packer et al and Sealy et al noted that when compared with 60Co, the much lower-energy photons (28 keV) emitted from 125I plaques were more rapidly absorbed in tissue and, therefore (for equivalent apex dose), reached fewer normal ocular structures. In this series, 103Pd offered even lower-energy photons than 125I and greater tissue penetration than 106Ru. Therefore, a switch from 125I to 103Pd seeds increased irradiation of the tumor, while simultaneously decreasing the amount of radiation to most normal ocular structures outside the targeted zone.

In addition, an 11-year study of 103Pd plaque radiotherapy for choroidal melanoma showed better visual results than those from centers using 125I. This is why we chose to use 103Pd for this study of plaque radiotherapy for medium-sized choroidal hemangiomas. If we were to treat larger hemangiomas (ie, >8 mm in height), we would choose the radiation treatment modality on the basis of comparative dosimetry. We expect that patterns of secondary radiation complications can be predicted by dosimetry studies, but proofs of these differences will require a large comparative clinical trial.

This study describes the first (to our knowledge) clinical experience with 103Pd ophthalmic plaque radiotherapy for symptomatic choroidal hemangioma. Anatomic and functional outcomes were documented for up to 29 months (mean, 18.6 months) of follow-up. Limitations of this study include the small number of patients and a relatively short follow-up. With longer-term follow-up, it is possible that radiation maculopathy may affect the visual acuity of patients irradiated for posterior uveal tumors (as seen in 1 patient in this study).

In this series, the mean best-corrected Early Treatment Diabetic Retinopathy Study visual acuity at the last follow-up improved by 2 lines. All patients had complete resolution of subretinal fluid with reattachment of the retina after a single treatment. All tumors decreased in height, with a mean decrease of 50% (from 3.3 to 1.7 mm at treatment).

This pilot study shows that a single 103Pd ophthalmic plaque radiation treatment is effective in eliminating subretinal fluid and improving vision in patients with symptomatic circumscribed choroidal hemangiomas.

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Correspondence: Paul T. Finger, MD, New York Eye Cancer Center, 115 E 61st St, New York, NY 10021 (pfinger@eye cancer.com).

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