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Visual acuity, oncologic, and toxicity outcomes with ^{103}Pd vs. ^{125}I plaque treatment for choroidal melanoma

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Abstract

PURPOSE—To evaluate outcomes of choroidal melanoma patients treated with ^{125}I or ^{103}Pd plaque brachytherapy.

METHODS AND MATERIALS—From 1993 to 2012, our institution treated 160 patients with ^{103}Pd (56.1%) and 125 patients with ^{125}I (43.9%) plaque brachytherapy. Tumor outcomes, visual acuity (VA), and toxicity were compared. Multivariate analyses (MVAs) and propensity score analysis were used to help address differences in baseline characteristics.

RESULTS—Median followup was longer for ^{125}I patients, 52.7 vs. 43.5 months ($p < 0.01$). At baseline, ^{103}Pd patients had lower rates of VA worse than 20/200 (4.4% vs. 16%, $p = 0.002$), T3–T4 tumors (17.5% vs. 32.8%, $p = 0.03$), and transpupillary thermotherapy use (3.1% vs. 9.6%, $p = 0.001$). Both ^{103}Pd and ^{125}I provided >90% 3-year overall survival and >93% 5-year secondary enucleation-free survival. On MVA, radionuclide was not predictive for tumor outcomes. A higher percentage maintained vision better than 20/40 with ^{103}Pd (63% vs. 35%, $p = 0.007$) at 3 years. MVA demonstrated ^{103}Pd radionuclide (odds ratio [OR]: 2.12, $p = 0.028$) and tumor height ≥ 5 mm (OR: 2.78, $p = 0.017$) were associated with VA better than 20/40. Propensity score analysis matched 23 ^{125}I with 107 ^{103}Pd patients. ^{103}Pd continued to predict better VA at 3 years (OR: 8.10, $p = 0.014$). On MVA for the development of VA worse than 20/200 or degree of vision loss, radionuclide was not significant. Lower rates of radiation retinopathy were seen with ^{103}Pd than ^{125}I (3 years: 47.3% vs. 63.9%, $p = 0.016$), with radionuclide significant in MVA.

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Conflict of interest: None.

CONCLUSIONS—Both ^{125}I and ^{103}Pd achieve excellent tumor control. An increased probability of long-term VA better than 20/40 and reduced risk of radiation retinopathy is associated with ^{103}Pd .

Keywords

Choroidal melanoma; Episcleral plaque brachytherapy; Palladium; Iodine

Introduction

Choroidal melanoma is the most common primary intraocular malignancy (1). For many years, enucleation was the standard therapy for patients with choroidal melanoma. From 1986 to 2003, the Collaborative Ocular Melanoma Study (COMS) group randomized patients with medium-sized tumors to enucleation or ^{125}I episcleral plaque brachytherapy (EPB). These studies demonstrated no difference in overall survival (OS) (2) and distant metastases (3). EPB, however, had more favorable visual acuity (VA) outcomes: 49% of these patients with baseline vision better than 20/40 retained VA of 20/40 or better at 3 years (4). Based on these results, the American Brachytherapy Society has recommended ^{125}I EPB as one alternative to enucleation for the treatment of medium size choroidal melanoma.

Although ^{125}I has demonstrated >85% 5-year local tumor control rates, 41–58% of patients develop significant deterioration in vision (vision > 20/200) in part due to radiation complications, including radiation retinopathy and vitreous hemorrhage (5, 6). ^{103}Pd is a lower energy gamma-emitting radionuclide with a shallower depth of penetration than ^{125}I (7); with this translating into less potential dose delivered to normal ocular structures (8–15), ^{103}Pd may decrease related radiation toxicity. Consistent with this hypothesis, Finger *et al.* first demonstrated in 2002 that 82% of patients ($n = 68$) treated with ^{103}Pd EPB had maintained VA of 20/200 or better at 3 years (16).

Based on these considerations, our institution began treating nearly all cases of choroidal melanoma with ^{103}Pd in 2004. As the COMS clinical trial excluded patients with tumors within 2 mm of the optic disc, ^{125}I was used for patients with tumors in contact with the optic nerve or those with very poor initial VA. ^{125}I —which is less expensive than ^{103}Pd —was also used in situations where cost was prohibitive. With no studies to our knowledge directly comparing patient outcomes after treatment with ^{103}Pd to ^{125}I plaque brachytherapy, the purpose of this study was to compare disease outcomes, VA, and toxicity of patients treated with these radionuclides at our institution.

Methods and materials

Patients

Following Institutional Review Board approval, we reviewed the charts of all patients treated with radionuclide eye plaques between 1993 and 2012. The following exclusion criteria were applied: patients with incomplete demographic, pretreatment VA or treatment data, iris or ciliary body melanoma, and patients with metastatic disease at initial presentation.

Treatment methods

For ^{125}I , ABS guidelines recommended prescribing 85 Gy to the apex, including for lesions less than 5 mm (5). The COMS study prescribed 85 Gy to 5 mm for lesion less than 5 mm in height; for tumors greater than 5 mm in height, the dose was prescribed to the tumor apex (2). At our institution, we followed the COMS approach. Plaque size (12) was chosen based on tumor size, allowing a 2-mm margin around the circumference of the tumor. For tumors close to the optic nerve, a notched plaque was chosen. Plaques were placed by oncologic ophthalmologist (authors TAM, TA, and CB) and were removed after 7 days. In an effort to maximize tumor control, transpupillary thermotherapy (TTT) was applied before or during iodine ($n = 33$) and palladium ($n = 11$) plaque brachytherapy. There was no selection bias relating to adding TTT to either radionuclide.

Statistics

Baseline patient data included age at time of treatment, gender, presence or absence of diabetes mellitus, best corrected VA before treatment, T stage (based on AJCC seventh edition staging manual), tumor area (length $\times$ width), height, and location (equator, posterior, equator/posterior, equator/anterior) and presence of retinal detachment. Treatment data included date of plaque placement, radionuclide used (^{125}I or ^{103}Pd), plaque size, plaque shape (notched vs. nonnotched), radiation dose, and prescription depth. Distance of the tumor from the optic nerve and fovea were also noted; these values are reported relative to the size of the globe to account for variations in cameras and images throughout the 20-year time period.

Followup data included length of followup, VA at annual followup visits, the date of diagnosis of complications of radiotherapy (radiation retinopathy or vitreous hemorrhage), distant metastases, secondary enucleation, and date of death from all causes of mortality.

Baseline and followup VA measurements were recorded using a Snellen VA scale. Count fingers VA was converted to a Snellen VA recording (17). Hand motion and light perception vision were recorded as a decimal acuity of 0.005, whereas no light perception and enucleation were given a decimal acuity of one line worse than the worst VA (0.0015) (18).

To determine the effect of radionuclides on VA, three VA measures were used: preservation, loss, and the degree of change. VA preservation was defined as posttreatment vision better than 20/40. VA loss was defined as impairment in vision to 20/200 or worse. Degree of VA loss was recorded as (1) improved, stable, (2) decrease in up to 1–2 lines on the Snellen chart (e.g., 20/30 to 20/40 = 1 line lost), (3) 3–5 lines, or (4) 6 lines. Patient characteristics were compared between those treated with ^{125}I and ^{103}Pd by two sample *t*-test for continuous variables and chi-square tests or Fisher's exact tests for categorical variables, where appropriate. VA preservation and loss were analyzed as dichotomous variables; rates were compared at 1 and 3 years utilizing chi-squared or Fisher's exact test. Time-to-event analyses were measured from the date of brachytherapy. Enucleation-free survival, distant metastases-free survival, and OS were estimated by the Kaplan–Meier product-limit method, and the log-rank test was used to assess the differences in distribution between patients treated with ^{125}I and ^{103}Pd . For radiation retinopathy analyses, patients were censored for

salvage enucleation. Covariates found to be significant or close to significant ($p < 0.20$) on univariate analysis were entered into the multivariate analysis (MVA), with radionuclide entered in last.

Additionally, we compared the iodine and palladium groups using a propensity score analysis. Patients with missing any clinical characteristic, baseline vision worse than 20/200, with a tumor height greater than 10 mm, or with TTT prior or concurrently were removed from this additional analysis. An inverse probability treatment weighting propensity score analysis was performed, where observations were reweighted based on a function of their propensity score. The propensity scores were derived using the following variables to predict treatment group: base diameter, T stage, age, tumor height, gender, receiving TTT, distance from tumor to optic nerve, distance from tumor to fovea, and baseline vision.

All analyses were carried out using the SAS 9.3 version statistical software package (SAS Inst., Cary, NC). All statistical analyses were two-sided, and p -values < 0.05 were considered statistically significant.

Results

Patient population, tumor, and treatment characteristics

Between 1993 and 2012, 285 patients with choroidal melanoma were treated with plaque brachytherapy. One hundred twenty-five patients were treated with ^{125}I (43.9%); 160 patients were treated ^{103}Pd (56.1%), with ^{103}Pd treatment commencing in 2004. Median followup time was 51.9 months (range 7.1–163.7) in the ^{125}I group and 43.5 months (range 6.8–119.8) in the ^{103}Pd group ($p < 0.01$). Table 1 summarizes the patients, disease, and treatment characteristics of each cohort. The ^{125}I cohort had larger tumors, as measured by larger median base area (136.6 mm² vs. 105.9 mm², $p < 0.01$), larger median height (4.6 mm vs. 2.9 mm, $p < 0.01$), and more advanced T stage (T3–T4, 32.8% vs. 17.5%, $p = 0.03$); furthermore, the ^{125}I group had more frequent TTT treatment before or with brachytherapy (9.6% vs. 3.1%, $p = 0.005$) and higher rate of baseline VA worse than 20/200 (16.0% vs. 4.4%, $p = 0.002$); VA better than 20/40 was similar ($p = 0.11$) between iodine (42.4%) and palladium (51.9%). Baseline retinal detachment was more common in the palladium cohort (32.5% vs. 17.6%, $p = 0.004$). Relative distance of the tumor to the fovea was similar between cohorts. Although close proximity to the optic nerve (i.e., 0–1 relative units) was also similar (18.4% vs. 15.0%), there were a greater number of unknown distance values in the ^{125}I cohort (29.6% vs. 1.3%, $p = 0.046$). The median prescribed dose was 85.3 Gy for ^{125}I and 84.6 for ^{103}Pd ; the median prescription point was 5 mm for both radionuclides.

Overall survival

Three-year OS was higher for the ^{103}Pd group in univariate analysis: 95.8% vs. 90.2%, $p = 0.047$ (Fig. 1). Larger T stage (T3/T4), tumor height > 5 mm, and age > 60 years old were significant for worse OS on univariate. On MVA, only tumor height demonstrated a trend toward significance (hazard ratio [HR]: 1.99, 95% confidence interval [CI]: 0.91–4.38, $p = 0.086$). Radionuclide did not independently predict for OS ($p = 0.889$).

Disease control

For the entire population, 18 (6.3%) patients underwent secondary enucleation: 2 (11.1%) were due to pain without evidence of progression, 15 (83.3%) were secondary to local progression alone, and 1 (5.6%) was due to regional progression with pain. Pathology reports from enucleation are only available starting in 2009; for these three cases, all were confirmed on pathology specimen to have viable melanoma. The 5-year rate of secondary enucleation-free survival was statistically lower for the ^{125}I cohort relative to the ^{103}Pd cohort in univariate analysis (93.0% vs. 99.3%, $p = 0.010$) (Fig. 2a). MVA analysis revealed tumor height >5 mm (HR: 4.54, 95% CI: 1.25–16.42, $p = 0.021$) as the only significant prognostic factors. Radionuclide was not a statistically significant independent predictor for secondary enucleation ($p = 0.170$).

At 3 years, rate of distant metastases-free survival did not differ between the ^{125}I and ^{103}Pd cohorts in univariate analysis (94.1% vs. 97.1%, $p = 0.254$) (Fig. 2b). MVA analysis revealed that tumor height >5 mm stage was the only statistically significant factor to predict for distant metastases (HR: 6.61, 95% CI: 1.81–24.09, $p = 0.004$); radionuclide did not independently predict for distant metastases ($p = 0.336$).

VA and MVA

At baseline, 27 patients had severe visual impairment, defined as VA worse than 20/200. The ^{125}I cohort had more patients with a severe visual impairment (16.0% vs. 4.4%, $p = 0.002$), but with no difference in the proportion with baseline VA better than 20/40 (42.4% vs. 51.9%, $p = 0.11$). At 3 years, all 27 patients continued to have vision worse than 20/200. As a result, this poor baseline VA subset was excluded for all analyses of posttreatment VA, leaving 258 eligible patients. Of these 258 patients, 152 (59%) had VA data available at 3 years.

At baseline, 82 ^{103}Pd patients and 53 ^{125}I patients had VA better than 20/40. At 3 years, the ^{103}Pd cohort (52/82, 63%) had a higher percentage to maintain VA better than 20/40 than the ^{125}I cohort (19/52, 35%) ($p = 0.01$). Table 2 details the factors included on MVA and their statistical significance for predicting for VA outcomes at 1 and 3 years. For predicting VA 20/40 or worse, MVA demonstrated ^{103}Pd radionuclide to be a significant predictor at 1 ($p = 0.017$) and 3 years ($p = 0.028$). Tumor height < 5 mm had a either a strong trend toward significance at 1 year ($p = 0.088$) and was significant at 3 years ($p = 0.017$).

Seventy-one ^{125}I patients and 111 ^{103}Pd patients had baseline vision better than or equal 20/200. At 3 years, the ^{125}I cohort had a trend toward developing higher rates of VA 20/200 or worse at 3-year followup (33.8% [$n = 24$] vs. 22.5% [$n = 25$], $p = 0.09$). MVA for VA loss demonstrated tumor height >5 mm as the only significant factor at 1 ($p = 0.025$) and 3 years ($p = 0.002$) (Table 2). Radionuclide did not independently predict for development of severe visual impairment at 1 or 3 years.

In comparing the degree of visual changes, at 3-year, the ^{103}Pd cohort had higher rates of improved vision, no change, or 1–2 lines of vision loss (65.5% vs. 52.5%) and lower rates of 6 lines of lost vision (10.8% vs. 27.5%, $p = 0.03$). MVA analysis for VA change of up to 1–

2 lines of visual loss demonstrated no significant predictors (Table 2). Radionuclide was not significant on MVA for predicting degree of VA change at 3 years ($p = 0.5$, respectively).

VA and propensity score

MVA suggests that ^{103}Pd radionuclide is a predictor for vision better than 20/40 at 1 and 3 years. To compare VA among more similarly identified patients, we used propensity score balancing and analysis. Twenty-three ^{125}I patients were matched with 107 ^{103}Pd patients. Table 3 shows that these groups are well balanced in regard to gender, tumor height, diameter, T stage, baseline vision <20/40, and relative optic nerve distance. The ^{103}Pd did have higher rates of retinal detachment (73.8% vs. 17.0%), whereas ^{125}I patients continued to have greater relative proximity to the fovea (34.5% vs. 10.7%, $p = 0.006$). Within this matched cohort, ^{103}Pd continues to be a significant predictor for VA preservation at 1 ($p = 0.042$) and 3 years ($p = 0.014$). Radionuclide was not a significant predictor for VA loss or changes in line vision.

Radiation retinopathy

Toxicity at 3 years or greater was evaluable in 195 patients (60.8%)—112 (57.4%) treated with Pd^{103} and 83 (43.6%) treated with I^{125} —with available information. Overall, 73 patients developed radiation retinopathy. Salvage treatment for toxicity included laser photocoagulation ($n = 15$), bevacizumab ($n = 15$), and vitrectomy ($n = 7$).

At 3 years, radiation retinopathy and vitreous hemorrhage occurred less in the ^{103}Pd cohort: 47.3% vs. 63.1%, $p < 0.001$ (Fig. 3). MVA demonstrated that ^{103}Pd radionuclide was significantly associated with lower risk of radiation toxicity (HR: 1.88, 95% CI: 1.02–3.47, $p = 0.043$). Tumor height >5 mm ($p = 0.968$), TTT ($p = 0.519$), and distance from the optic nerve to tumor ($p = 0.810$) did not predict for higher risk of radiation retinopathy. No differences in rates of salvage treatments were seen between cohorts.

Discussion

Since the COMS study, ^{125}I EPB has been incorporated as a treatment option for potential eye/vision preservation for small and medium choroidal melanoma patients. However, despite 70% of patients having baseline VA 20/40 or better, only 34% of patients (49% of the 20/40 cohort) maintained 20/40 vision or better at 3 years (4). This demonstrates that there is substantial room for further improvement in post-EPB VA while maintaining oncologic outcomes.

To directly compare ^{125}I and ^{103}Pd , we investigated the VA of 258 patients with choroidal melanoma and baseline vision better than or equal to 20/200 treated with EPB at our single institution. We demonstrated that ^{103}Pd cohort was associated with higher rates of visual preservation (defined as better than 20/40) at 3 years (39.6% vs. 19.1%, $p = 0.006$), with radionuclide remaining significant in adjusted MVA. Furthermore, within a more balanced cohort of patients—as created by propensity score analyses— ^{103}Pd continued to predict for improved VA preservation at 1 and 3 years. We also demonstrated that ^{103}Pd was associated with a significantly lower risk of retinopathy at 3 years (39.6% vs. 71.6%, $p < 0.001$), with ^{103}Pd radionuclide remaining a strong predictor of reduced toxicity on adjusted MVA.

Though radionuclide independently and significantly predicted for VA preservation, it was not associated with degree of VA change or loss. Finally, the improved visual outcomes with ^{103}Pd did not come at a detriment to oncologic outcomes: on adjusted analyses, ^{103}Pd was not a predictor for secondary enucleation, distant metastases, or OS.

^{103}Pd , due to its lower energy resulting in quicker dose fall-off, has been demonstrated dosimetrically to decrease dose to the macula and optic nerve relative to the ^{125}I (7). Finger *et al.* subsequently investigated if this physical advantage translated into a clinical benefit. At 3 years, only 17.6% of ^{103}Pd patients developed vision worse than 20/200 (19), compared with 43% of ^{125}I patients at 3 years on the COMS medium study (4). The authors concluded ^{103}Pd likely has higher rates of visual preservation than ^{125}I ; there are, however, many potential issues with this comparison including differences in baseline VA and patient comorbidities, tumor characteristics, and comparison of a retrospective cohort to an intention-to-treat phase III trial. Our study builds on the findings by Finger *et al.* by directly comparing patients treated with ^{103}Pd to ^{125}I . We demonstrate that ^{103}Pd is associated with improved VA and decreased radiation retinopathy; these results, however, are probably due in part to selection bias and difference in patient characteristics. However, these finding, especially in light of both MVA and propensity score balancing, is provocative and suggests that choice of radionuclide may help better maintain vision <20/40. Though radionuclide independently and significantly predicted for VA preservation, it was not associated with degree of VA change or VA loss (defined as VA worse than 20/200).

Limitations of this study include its retrospective design, potential for selection bias due to the nonrandomized treatment cohorts, difference in time periods of patient treatment (with ^{103}Pd use starting in 2004), and differences in baseline patient and tumor characteristics and median followup periods between cohorts. Moreover, although we accounted for numerous variables known to be predictive for visual outcomes after EPB, many patients had missing data; these unknown missing values—higher in the iodine cohort—for retinal detachment and distance to optic nerve and fovea, likely further contributed to our observed VA differences. We did attempt to minimize difference in baseline prognostic differences using two separate statistical models: multivariable analyses and propensity score balancing; however, our statistical measures cannot completely overcome these important differences. Strengths of this study include its relatively large patient numbers, homogenous patient treatment methods and followup/surveillance schedule, and well-documented patient, tumor, and treatment characteristics for use in MVA to adjust for potential confounding variables. To our knowledge, we also are the first to report on oncologic and VA outcomes directly comparing, albeit retrospective cohort study, ^{103}Pd with ^{125}I EPB.

In conclusion, treatment with either ^{125}I or ^{103}Pd results in excellent tumor control and low rates of secondary enucleation. However, ^{103}Pd radionuclide use was associated with increased probability of long-term VA preservation and reduced risk of radiation retinopathy compared with ^{125}I . Additionally, tumor height is a strong significant predictor of VA outcomes, toxicity outcomes, and local control probability, most likely due to both tumor bulk and radiation dosimetry factors. As this study is subject to limitations common to all retrospective reviews, a prospective clinical trial comparing EPB radionuclides is warranted.

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Isotope	No. of Subject	Event	Censored	Median Survival (95% CI)	12 Mo Survival	36 Mo Survival	60 Mo Survival
Iodine	125	39 (31%)	86 (69%)	120 (88.2, 181.9)	100.0% (NA, NA)	90.2% (83.1%, 94.5%)	80.1% (70.6%, 86.8%)
Palladium	160	15 (9%)	145 (91%)	NA (NA, NA)	99.4% (95.6%, 99.9%)	95.8% (90.8%, 98.1%)	84.7% (74.7%, 91.0%)

Fig. 1.

Estimated overall survival for treatment with ^{125}I compared with ^{103}Pd . Curve is truncated at 84 months. CI = confidence interval.

Fig. 2. Estimated secondary enucleation (a) and distant metastases-free survival (b) for treatment with ^{125}I compared with ^{103}Pd . Curve is truncated at 84 months.

Isotope	No. of Subject	Event	Censored	Median Survival (95% CI)	12 Mo Survival	36 Mo Survival	60 Mo Survival
Iodine	125	75 (60%)	50 (40%)	32.5 (28.7, 45.7)	83.6% (75.7%, 89.1%)	47.3% (37.4%, 56.6%)	29.7% (20.2%, 39.8%)
Palladium	160	74 (46%)	86 (54%)	54.2 (39.3, 58.8)	97.4% (93.3%, 99.0%)	63.1% (54.3%, 70.8%)	39.0% (28.8%, 49.1%)

Fig. 3.
Estimated rate of developing radiation retinopathy or vitreous hemorrhage with ^{125}I compared with ^{103}Pd . Curve is truncated at 60 months.

Table 1

Baseline patient characteristics

Covariates	¹²⁵ I (n = 125)	¹⁰³ Pd (n = 160)	p-value
Gender (%)			
Male	72 (57.6)	81 (50.6)	0.24
Female	53 (42.4)	79 (49.4)	
Median age (y)	64 (range: 16–93)	64 (range: 23–87)	0.96
Diabetes (%)			0.73
Yes	18 (14.5)	20 (13.1)	
No	107 (85.5)	140 (86.9)	
Laterality (%)			
OS	65 (52.0)	76 (47.5)	0.45
OD	60 (48.0)	84 (52.5)	
Visual acuity (20/X) (%)			
20	24 (19.2)	37 (23.1)	0.15
>20–<50	47 (37.6)	68 (42.5)	
50–<100	20 (16.0)	35 (21.9)	
100–500	23 (18.4)	16 (10.0)	
500	5 (4.0)	2 (1.3)	
CF	3 (2.4)	0 (0)	
HM	2 (1.6)	2 (1.3)	
LP	1 (0.8)	0 (0)	
Visual acuity (%)			
20/200	105 (84.0)	153 (95.6)	<0.01
>20/200	20 (16.0)	7 (4.4)	
Location (clock position) (%)			
12:00–3:00	38 (30.4)	42 (26.3)	0.43
3:30–6:00	33 (26.4)	36 (22.5)	
6:30–9:00	31 (24.8)	54 (33.8)	
9:30–11:30	23 (18.4)	28 (17.5)	
Location (globe position) (%)			
Equator	30 (30.4)	49 (30.6)	0.28
Posterior	17 (13.6)	18 (11.3)	
Equator and posterior	47 (37.6)	76 (47.5)	
Equator and anterior	21 (16.8)	15 (9.4)	
Ora Serrata	2 (1.6)	2 (1.3)	
Median base area (mm ²)	136.6 (range: 13.5–312.8)	105.9 (range: 0.1–1075.8)	<0.01
Median height (mm)	4.6 (range: 1.1–13.5)	2.9 (range: 0.7–10.3)	<0.01
T stage (%)			
1	9 (7.2)	17 (10.6)	0.03
2	75 (60.0)	115 (71.9)	
3	39 (31.2)	27 (16.9)	

Covariates	¹²⁵ I (n = 125)	¹⁰³ Pd (n = 160)	p-value
4	2 (1.6)	1 (0.6)	
TTT treatment (%)			
Yes	15 (12.5)	5 (3.1)	<0.01
No	110 (87.5)	155 (96.9)	
Relative distance to the fovea (%)			0.45
0	16 (12.8)	16 (10.0)	
0 < x < 1	9 (7.2)	19 (11.9)	
1–3	28 (22.4)	52 (32.5)	
>3	35 (28.9)	71 (44.4)	
Unknown	37 (29.6)	2 (1.3)	
Relative distance to optic nerve			0.046
0	13 (10.4)	13 (8.1)	
0 < x < 1	10 (8.0)	11 (6.9)	
1–3	32 (25.6)	59 (36.9)	
>3	33 (26.4)	75 (46.9)	
Unknown	37 (29.6)	2 (1.3)	
Retinal detachment (%)			0.004
Yes	22 (17.6)	52 (32.5)	
No	47 (37.6)	69 (43.1)	
Not recorded	56 (44.8)	39 (24.4)	
Median delivered dose (Gy)	85.3 (range: 80.9–100.8)	84.6 (range: 80.7–88.5)	0.047
Median prescription point (mm)	5 (range: 2.8–13.5)	5 (range: 3.6–10.4)	<0.01
Median plaque size (mm)	18 (range: 14–22)	18 (range: 14–24)	0.35

OS = oculus sinister (left eye); OD = oculus dexter (right eye); CF = counting fingers; HM = hand motion; LP = light perception; TTT = transpupillary thermotherapy.

Bold *p* values denote <0.05.

Table 2

Multivariate analysis for visual outcomes at 1 and 3 years

Visual outcomes	Variable	OR*	95% CI	p-value
1 years				
Preservation	Isotope: ^{103}Pd vs. ^{125}I	2.70	1.20–6.25	0.02
	Tumor height: >5 mm vs. ≤5 mm	2.04	0.90–4.55	0.09
Change in vision	Isotope: ^{103}Pd vs. ^{125}I	1.44	0.41–5.26	0.55
	Tumor height: >5 mm vs. ≤5 mm	0.56	0.16–1.89	0.35
	Prior TTT: yes vs. no	0.45	0.08–2.49	0.36
Loss	^{103}Pd vs. ^{125}I	1.45	0.66–3.57	0.32
	Tumor height: >5 mm vs. ≤5 mm	0.59	0.26–1.35	0.21
	Prior TTT: yes vs. no	0.16	0.03–0.84	0.03
	Distance from optic nerve: >1 vs. 0–1	0.64	0.27–1.51	0.31
3 years				
Preservation	Isotope: ^{103}Pd vs. ^{125}I	2.13	1.09–4.17	0.03
	Tumor height: >5 mm vs. ≤5 mm	2.78	1.20–6.25	0.02
	Notched plaque	2.50	0.97–6.25	0.06
Change in vision	Isotope: ^{103}Pd vs. ^{125}I	1.72	0.78–3.85	0.18
	Tumor height: >5 mm vs. ≤5 mm	0.47	0.19–1.15	0.10
	Prior TTT: yes vs. no	0.42	0.11–1.62	0.21
	Distance from optic nerve: >1 vs. 0–1	3.78	1.03–13.84	0.05
Loss	^{103}Pd vs. ^{125}I	1.45	0.65–3.23	0.35
	Tumor height: >5 mm vs. ≤5 mm	0.28	0.12–0.64	0.00
	Prior TTT: yes vs. no	0.85	0.30–2.43	0.77
	Distance from optic nerve: >1 vs. 0–1	3.40	1.27–9.11	0.02

TTT = transpupillary thermotherapy; CI = confidence interval;

* OR = odds ratio.

Bold *p* value denotes <0.05.

Preservation: posttreatment acuity better than 20/40.

Loss: posttreatment acuity worse than 20/200.

1–2 degrees of change: posttreatment acuity improved, stable, or decreased by up to 1–2 lines on Snellen chart.

Table 3

Propensity score analysis, balance check

Covariate	Reference level	¹²⁵ I <i>N</i> = 23 (%)	¹⁰³ Pd <i>N</i> = 107 (%)	Standardized difference
Maximum base diameter	<16 mm	87.8	97.9	0.399
T stage	T1/2	83.5	91.6	0.246
Age	<60	26.1	54.9	0.612
Tumor height	<5 mm	78.1	92.3	0.410
Gender	Male	38.9	48.5	0.195
Relative distance from optic nerve to tumor	Ratio 1	24.12	13.6	−0.272
Relative distance from fovea to tumor	Ratio 1	34.5	10.7	−0.590
Baseline vision	<20/40	48.7	57.7	0.181
Retinal detachment	Yes	17.0	73.8	−1.386