Plaque-Mounted Diode-Light Transillumination for Localization Around Intraocular Tumors

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Objective: To evaluate the usefulness of plaque-mounted diode-light transillumination (DLT) for the localization of episcleral plaques around intraocular tumors.

Methods: A clinical case series was performed to create, evaluate, and modify diode-light plaque construction, application, and imaging. Eight patients with choroidal melanoma were offered DLT as an additional method of ophthalmic plaque localization. Plaques were constructed by affixing non-heat-producing, light-emitting diodes with their apertures flush with the episcleral outer surface of the rim of the plaque. A bioimplantable epoxy was used to encapsulate the electronic components. Radioactive DLT eye plaques were sewn to the episclera to cover the base of the intraocular tumors; then diode lights were illuminated, viewed, and recorded. Thus, DLT was used to photographically document the relative position of the eye plaque covering the tumor base. The use of DLT also permitted a subjective evaluation of the contact (plaque contact) of each light with the sclera.

Results: Still and video images of plaque-mounted diode retro-transillumination were obtained, and no evidence of toxic effects of diode light were noted.

Conclusions: Small posterior melanomas are difficult to visualize with standard transillumination techniques and are associated with poor local control. To improve and document plaque placement, we developed plaque-mounted diode lights for retrobulbar transillumination. This technique provides unique photographic documentation of episcleral plaque localization beneath intraocular tumors.


**PLAQUE RADIOTHERAPY is the most frequently used “eye-sparing” treatment for choroidal melanoma.** Most eye plaques consist of radioactive seeds affixed in a bowl-shaped gold shell. After a radioactive plaque is sewn to the sclera overlying an intraocular tumor, the gold shell is known to block more than 99.95% of iodine 125 or palladium 103 (103Pd) radiation traveling in any direction other than toward the episcleral surface. While the gold of the eye plaque blocks unnecessary irradiation behind and to the sides of the plaque, it also necessitates more precise localization to cover the base of the tumor.

Intraocular tumor localization has relied on transocular or transpupillary illumination of the eye. While an eye is illuminated, the tumor thickness and pigmentation create a dark shadow, which can be visualized on the eye wall. In most cases, transillumination of anterior intraocular tumors can be performed with ease and offers an excellent method to ensure proper plaque localization. In contrast, posterior intraocular tumors are the most difficult to localize and may necessitate the use of ophthalmoscopy with scleral depression, ultrasonography, or both. Difficulties with plaque placement beneath posterior tumors may contribute to higher rates of local radiation failure.

Plaque placement is critical to successful radiation therapy. Reports suggest that failure of local control may reduce a patient’s chance of survival. Therefore, methods to ensure proper plaque placement at the time of plaque insertion are critical.

The purpose of this study was to evaluate the usefulness of plaque-mounted diode-light transillumination (DLT) for the localization of episcleral plaques around intraocular tumors. We describe how to construct, use, and photographically document the implantable device, as well as assess the position of the diode eye plaque in relation to the intraocular tumor.
MATERIALS, PATIENTS, AND METHODS

DLT PLAQUE CONSTRUCTION AND POWER SUPPLY

We used standard gold eye plaques (Trachsel Dental Studios, Rochester, Minn) individually modified so as to affix 2 non-heat-producing, light-emitting diodes (Lumex SSL-LXA288SRC-TR1125; Opto/Components Inc, Palatine, Ill; angle of dispersion, 25°; clear lens; 170 millicandelas at 20 mA; 660 nm) by encapsulation with spectrally transparent bioimplantable epoxy (Epotec-301; Epoxy Technology Inc, Billerica, Mass). A 2-conductor female connector was used (Nanoseries A7471-001; Omnetics Connector Inc, Minneapolis, Minn) to attach the power supply cord. Each diode aperture was oriented so as to be flush with the episcleral surface. Then all components (except the connector) were encapsulated. Thus, the components (wires, diodes, and solder) were completely encapsulated in medical-grade epoxy to separate them from the patient’s tissues at the time of DLT and throughout plaque implantation.

Although more lights at different distances could have been used, we chose to affix 2 lights at an 8-mm cord-length separation distance from the fellow light. The diode lights were wired in parallel. Once the diode lights were attached and the epoxy dry, the requisite number of radioactive seeds (103Pd; TheraGENICs Corporation, Norcross, Ga) were affixed (with a thin layer of medical-grade adhesive) onto the inner surface of the eye plaque (Trachsel Dental Studio Inc, Rochester, Minn). The diode lights were powered by a handheld external power supply cord. Each diode aperture was oriented so as to be flush with the episcleral surface (Figure 1). Then all components (except the connector) were encapsulated. Thus, the components (wires, diodes, and solder) were completely encapsulated in medical-grade epoxy to separate them from the patient’s tissues at the time of DLT and throughout plaque implantation.

Institutional review board approval was obtained before the present study was initiated, and each patient gave informed consent to participate. Eight patients were selected for plaque-mounted DLT because they had tumors located behind the equator. All tumors were treated at the New York Eye and Ear Infirmary, New York, NY, and all patients underwent ophthalmic plaque brachytherapy surgery that was performed by one of us (P.T.F.).

DLT PLAQUE INSERTION AND REMOVAL

Before surgery, indirect ophthalmoscopy was used to confirm the presence, location, and condition of the tumor and the affected eye. A wire-lid speculum was placed on the eye, and a transconjunctival approach to the episclera was used. As possible, standard transillumination was used to delineate tumor margins. Transpupillary and transocular transillumination techniques were used. Marks were made on the episclera at the edges of the transillumination shadow. Then, a 2- to 3-mm shadow-free margin was marked on the episclera around the base of the tumor. Four interrupted episcleral sutures were used to anchor the plaque to the sclera with its edges covering the tumor and its shadow-free margin. The female connector attached to the direct current power supply was grasped with smooth forceps and attached to the male connector anchored to the plaque (Figure 2). At this time, transscleral DLT was performed (Figure 3). At the end of DLT, the female connector and cable were disengaged before conjunctival closure.

Since the information obtained in the present study was unique, it was not (in itself) used to change plaque placement. In the present study, if the plaque position seemed suboptimal by DLT, plaques were repositioned by using standard transillumination and ultrasonography and then reassessed by DLT. Thus, DLT was used to confirm our standard methods of plaque localization and to document plaque location. At the end of surgery, disinserted rectus muscles were affixed to the sclera or returned to their natural positions. The conjunctiva was closed. When radiation therapy was completed, all 8 DLT eye plaques were removed and found to be intact.

RESULTS

DIODE-LIGHT TRANSILLUMINATION

During plaque-mounted DLT, the intensity of light was modulated such that 2 distinct point sources could be visualized. In each case, they were noted to be located beyond the posterior edge of the tumor (Figure 3). Since we knew that the sources were 8 mm apart and attached to the gold shell, it was reasonable to assume the relative position of the episcleral plaque and the intraocular tumor (Figure 3). By the end of plaque insertion, the results of standard transillumination, ultrasonography, and DLT were consistent with optimum plaque placement.

During ophthalmoscopy and video capture we noted that the image could be optimized if the light from the indirect ophthalmoscope was minimized (not completely extinguished). Other factors that affected DLT included the contact of the plaque with the sclera. It was our impression that plaque tilt and soft tissue (eg, the inferior oblique muscle) diffused the light, making it less of a point source. This finding could be used to assess and optimize contact between the rim of the eye plaque and the episclera.

VIDEO INDIRECT VS RETCAM 120 IMAGING

We found certain limitations imposed by the indirect ophthalmoscopy-based video-imaging systems. The field of view was relatively narrow (simultaneous viewing of both lights was difficult), image quality was dependent on corneal clarity, and some degradation of the acquired images related to processing the digital image. Typically, more than 30 images were recorded to obtain a few quality photographs.

The digital imaging system (RetCam 120; Massie Research Laboratories, Inc, Pleasanton, Calif) permit-
A wide-angle view of the fundus (Figure 4), a perspective that permitted us to clearly view, record, and optimize both light sources in relation to the intraocular tumors (Figure 5). It also led us to consider adding 2 additional lights for subsequent studies. Image clarity with the RetCam 120 also was found to be dependent on corneolenticular clarity. Overall, digital photography improved our capacity to create photographic-quality images, store data, and transmit files over the Internet.

Like standard transillumination, diode lighting produced no observable scleral, choroidal, or retinal toxic effects. No lesions were visible on the episclera at the time of plaque removal, no chorioretinal lesions have been noted with subsequent ophthalmoscopy, and the vision of our patients has been unaffected by DLT. Diode lights were never located directly beneath the fovea in any patient in the present study.

Figure 1. The anterior face of a radioactive diode-light transillumination ophthalmic plaque. A, Note the diode light (arrow) affixed to the outer rim of the plaque with its aperture set to approximate the episcleral edge of the plaque. B, The posterior aspect of the plaque. Note the wires encapsulated in medical-grade epoxy and the position of the connector (arrow).

Figure 2. Intraoperative external photograph showing the female connector of the power cord attached to the male connector on the gold plaque.

Figure 3. The process of transscleral diode-light transillumination (Anthony M. Pazos, medical illustrator, Tucson, Ariz).

**COMMENT**

**DLT VS OTHER FORMS OF PLAQUE LOCALIZATION**

Magnetic resonance imaging (MRI) and ultrasonography also have been used to assess the episcleral plaque position under intraocular tumors.⁸⁻¹¹,¹⁸⁻²⁰ Their advantages include the ability to obtain or construct images of the plaque and the tumor that can be viewed in multiple orientations.¹¹ But compared with fundus photography, ultrasonography and magnetic resonance imaging offer relatively poor resolution of the base of the tumor. Ultrasonographic images can be influenced by angles of incidence and acoustic impedance, and magnetic resonance imaging is impractical in the operating room.

Finger et al¹¹ found that 3-dimensional ultrasonography provided unique images of episcleral plaque and
radioactive seed position relative to intraocular tumors. The ability to replay and analyze the reconstructed 3-dimensional volume that contains the tumor, the gold plaque, and the seeds has enhanced our ability to determine proper plaque centration.11 Despite these new capabilities, DLT complements ultrasonography by offering the only method to directly visualize and document the episcleral plaque position with fundus photography.

Fiberoptic light pipes also have been used to localize episcleral plaques.12,13,21 One disadvantage of light pipes is that they are not attached to the plaque. This technique always leaves some doubt about the proximity of the light source to the edge of the plaque. In contrast, DLT offers a higher intensity light from multiple smaller (1-mm) apertures, which are attached to the plaque. If the surgeon constructs a mental image of a line between the 2 lights and knows where the lights were attached to the plaque, the surgeon can determine the plaque’s orientation behind the intraocular tumor. Both forms of localized transillumination are affected by sclera-induced light diffraction.

**LOCALIZATION OF ANTERIOR INTRAOCULAR TUMORS**

Most anterior intraocular tumors can be localized by standard transillumination techniques. Drawbacks of low-frequency ultrasonography, transillumination, and scleral depression techniques originate from their relative inability to define anterior tumor margins that extend into the ora serrata, the ciliary body, and iris. Standard transillumination shadows merge with the highly pigmented and thickened ciliary body. Ultrasonography has not been used successfully to image anterior tumor margins, because (when sewn to the episclera) the gold plaque overhangs and obscures the tumor.

In contrast, DLT spots or lights located anterior to the equator could be imaged with indirect ophthalmoscopy, but in these cases, fundus photography would be difficult. Last, patients with large anterior tumors that overhang and obscure the posterior pole (and, therefore, the lights), also would be poor candidates for DLT.

**LOCALIZATION OF POSTERIOR INTRAOCULAR TUMORS**

Patients with posterior and amelanotic intraocular tumors are most likely to benefit from DLT. In these cases, transocular or transpupillary transillumination can fail to define the location of the tumor, or only the anterior tumor margin can be marked on the episclera. In the treatment of small posterior tumors, ophthalmic oncologists must rely on scleral depression with ophthalmoscopy or ultrasonography. For these tumors,
DLT offers a new method to define the posterior margin of the plaque relative to the tumor, the fovea, and the optic nerve.

In the treatment of juxtapapillary tumors, ultrasonography has demonstrated that the posterior margin of the plaque can slide along the soft tissues around the optic nerve and “tilt” back. Since DLT offers a subjective assessment of posterior plaque apposition to the sclera, it also offers a method to assess and, therefore, address plaque tilt.

The present study demonstrated that DLT offers unique views of episcleral plaques beneath choroidal melanomas. While DLT has some of the same limitations that affect fundus photography, it offers the potential to improve plaque localization. Photographs obtained during DLT offer the only current method to photographically document plaque placement after insertion. Such photographic documentation of plaque placement can be used as a measure of quality control and to reassure patients that the plaque was placed accurately.

Although standard transillumination of the eye remains essential for accurate ophthalmic plaque localization, the posterior margins of uveal melanomas are often difficult or impossible to visualize. A combination of standard transillumination to define the anterior margin and DLT to assess the posterior margin allows the surgeon a method to assess all tumor margins.

Diode-light transillumination should be particularly helpful for plaque localization in treatment of smaller uveal melanomas. Many small posterior melanomas cannot be visualized with standard transillumination techniques. In these cases, DLT can play an important role as an adjunct to scleral depression and ultrasonographic imaging for the localization of radioactive eye plaques.

We will continue to use this method of plaque-mounted DLT for localization of episcleral plaques. Further research will be needed to evaluate the use of additional lights and for localization around irregular tumors in varied intraocular locations.

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REFERENCES


From the Archives of the Archives

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STEFFAN opposes the idea of amblyopia ex anopsia, recognizing only congenital amblyopia. The operative treatment of squint should be undertaken only when all other means of obtaining the desired result fail. Until the refraction of a child has become fixed, one should not operate. The earlier the operation, the less certain will be the ultimate result.