Neodymium–YAG Transscleral Cyclophotocoagulation

The Role of Pigmentation

Louis B. Cantor,* Dan A. Nichols,† L. Jay Kanz,J Marlene R. Moster,‡ Effie Poryzees,‡ Jerry A. Shields,§ and George L. Spaeth‡:

Using a rabbit model we investigated the role of pigmentation in obtaining ciliodesstruction by neodymium–YAG transscleral cyclophotocoagulation. There was marked destruction of the ciliary body in pigmented rabbit eyes, but no histologic effect was observed in albino rabbit eyes. These findings suggest that pigmentation of the ciliary body is important for obtaining the desired response from neodymium–YAG transscleral cyclophotocoagulation in rabbit eyes by our technique. Further study is necessary to define the role of pigmentation in human eyes in this treatment modality.


Neodymium–YAG transscleral cyclophotocoagulation is a ciliodestructive procedure designed to lower intraocular pressure by reducing aqueous production. Clinical studies using this technique as an alternative to cyclocryotherapy have demonstrated promising, though variable results in the treatment of various intractable glaucomas.1–3 Little is known of the biologic variables that may affect this procedure. The following study was designed to investigate the role of pigmentation in obtaining destruction of the ciliary body by this treatment modality in an animal model.

Materials and Methods

Neodymium–YAG transscleral cyclophotocoagulation was performed in three albino and three Dutch-belted rabbits in accordance with the ARVO Resolution on the Use of Animals in Research. A total of five eyes in each type of rabbit were treated, with one eye remaining untreated to serve as histologic control. The animals were sedated with intramuscular ketamine and acepromazine. The procedure was performed using the Lasag (Thun, Switzerland) Microruptor II Neodymium–YAG laser in the free-running (thermal) mode with pulse energies of 1.95 to 2.15 joules per burst. Sixteen applications of single bursts were placed over 4 clock hours in each treated eye, approximately 1 mm from the corneoscleral limbus. The laser beam was retrofocused approximately 2.8 mm posterior to the aiming beam, using the retrofocus capability on the Lasag Microruptor at a setting of seven, and the treatment was performed as perpendicular to the sclera as possible. The rabbits were then sacrificed and eyes were sectioned for histopathologic study at 2 hr, 1 week and 1 month following the procedure.

Results

No histopathologic effects were seen in any of the treated albino rabbit eyes at 2 hr, 1 week or 1 month following the procedure. There was no evidence of inflammation or disruption of the pigmented or nonpigmented ciliary epithelium or vascular network (Fig. 1).

In the treated area of the pigmented rabbit eye at 1 week, the superficial scleral and episcleral tissues were diffusely infiltrated with mononuclear blood cells and numerous small blood vessels were ramifying through the superficial tissues, suggesting chronic inflammation and vascularization. The stroma of the ciliary body revealed marked vascularity and hemorrhage with increased cellularity due to scattered chronic inflammatory cells. There was extensive pigment dispersion and destruction of the stromal melanocytes. The overlying ciliary processes revealed marked disruption with extreme necrosis of the pigmented epithelium. There was thickening of the pig-
Fig. 1. Albino rabbit eye 1 week following treatment. No histopathologic effect was discernible. Note that the ciliary processes in the normal rabbit eye are anteriorly displaced and are located on the posterior surface of the peripheral iris (hematoxylin and eosin; X10).

Fig. 2. Control Dutch-belted rabbit eye demonstrating normal architecture and heavy pigmentation (hematoxylin and eosin; X10).

ment epithelium basement membrane with scattered hemorrhage into the vitreous overlying the treated area (Figs. 2, 3).

In the treated area of the pigmented rabbit eye at 1 month there was minimal episcleral chronic inflammation. The ciliary body revealed marked necrosis with replacement by fibrous connective tissue. There was pigmentary disruption of the stroma and the ciliary processes were either degenerated or atrophied. There was minimal inflammation within the ciliary body and no vitreous hemorrhage overlying the treated area (Fig. 4).

Discussion

When the neodymium-YAG laser is used in the free-running, thermal mode, the effect of the laser is
much different than when it is used in the Q-switched nonthermal mode. The slower pulse duration of 20 msec used in the free-running mode does not cause plasma formation or create a shock wave leading to mechanical damage and focal degeneration of the target tissue, as is characteristic of neodymium–YAG laser treatment using nanosecond pulses typical for posterior capsulotomies or peripheral iridectomies.

Instead, the laser energy in the thermal mode must be absorbed by pigment in the target tissue and converted into heat to create an effect. The 1060 nm wavelength of the neodymium–YAG laser has low absorption and high transmission in water and blood, allowing it to penetrate nonpigmented, hydrated tissues with minimal absorption. This property allows the laser to penetrate the sclera and other similar tis-

Fig. 3. Dutch-belted rabbit eye 1 week following treatment. There is marked disruption and hemorrhagic necrosis of the ciliary processes and ciliary epithelium (hematoxylin and eosin; X10).

Fig. 4. Dutch-belted rabbit eye 1 month following treatment. There has been replacement of the ciliary processes by fibrous connective tissue with minimal residual inflammation (hematoxylin and eosin; X10).
sues with little loss of energy. The effects of thermal mode neodymium–YAG laser have been reported in pigmented rabbits, but little has been reported in nonpigmented animal models.\textsuperscript{5–7}

In albino rabbit eyes where there is minimal or no pigmentation of the ciliary body stroma or ciliary epithelium, neodymium–YAG transscleral cyclophotocoagulation had no visible histopathologic effects in these tissues in this study. In Dutch-belted rabbit eyes, where there is heavy pigmentation of both the ciliary body stroma and pigmented ciliary epithelium, there was marked destruction of the ciliary body as a result of the transscleral neodymium–YAG cyclophotocoagulation.

The implication of our findings in human eyes is unknown. There are significant differences between the rabbit and human ciliary anatomy. In the rabbit the frond-like ciliary processes are located on the posterior peripheral iris and are therefore more removed from the laser entry site. In human eyes the laser energy must pass through the ciliary body stroma in order to reach the ciliary processes. In normal human eyes, pigmentation of the pigmented ciliary epithelium is rather constant; however, there is wide variation in the pigmentation of the ciliary body stroma. It is not known whether it may be optimal for most of the energy to be absorbed in the ciliary body stroma, in the ciliary epithelium, or in both to achieve a good ciliodestructive effect by neodymium–YAG transscleral cyclophotocoagulation. If the primary effect needed to obtain a good result from neodymium–YAG cyclophotocoagulation is direct necrosis of the ciliary epithelium, then an individual who has minimal pigmentation of the ciliary body stroma may obtain a better result because the energy can penetrate through the stroma to the ciliary epithelium. In contrast, if it is more important for the energy to be absorbed within the ciliary body stroma to obtain a good response to treatment, then an individual may do better by having maximum absorption of the laser energy within a heavily pigmented stroma.

This is the first study to identify a biologic variable that directly affects the response to neodymium–YAG cyclophotocoagulation. This finding may affect patient selection for this procedure and it is possible that an adjustment in the power setting may be predicted based on clinical estimates of the degree of ciliary body pigmentation by noting iris color or pigmentation of the fundus. Attention to ocular pigmentation as well as other variables may allow a better understanding of the results obtained with this procedure.

**Key words:** neodymium YAG laser, cyclophotocoagulation, ciliary body, transscleral, ciliodestruction

**References**