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The Microendoscope for Ciliary Process Photocoagulation in Neovascular Glaucoma

Kenji KAWAI

Department of Ophthalmology, Ohgaki Municipal Hospital, Gifu

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The safety and efficacy in endoscopic ciliary body photocoagulation was evaluated in 6 patients with intractable neovascular glaucoma secondary to proliferative diabetic retinopathy. After a mean follow-up of 8 weeks, the mean intraocular pressure (IOP) decreased from 39.2 ± 5.0 mmHg preoperatively to 19.5 ± 3.8 mmHg postoperatively ($p < 0.05$, Wilcoxon signed-ranks test). Although intense inflammation was observed as an immediate postoperative complication, fibrin, eye pain and phthisis did not develop in any of the patients.

Key words : Endoscopic ciliary process photocoagulation, Neovascular glaucoma, Proliferative diabetic retinopathy

INTRODUCTION

Although intractable glaucoma was previously treated with cyclocryotherapy to reduce the production of aqueous humor by the ciliary body, recent advances of laser surgery have resulted in the wide use of trans-scleral cyclophotocoagulation with a semiconductor laser for the treatment of glaucoma. However, excessive coagulation and destruction of the ciliary body by cyclophotocoagulation can cause postoperative complications, such as severe inflammation of the anterior chamber with fibrin deposition, anterior chamber hemorrhage, and ocular pain. To solve these problems, the Micro Probe (Endo Optiks) was developed by Dr. Martin Uram who combined an endoscope and a laser photocoagulation device [1]. Since this apparatus provides a direct view of the ciliary pars plicata during photocoagulation, it allows surgeons to perform cyclophotocoagulation with much less laser energy than the trans-scleral technique.

This paper reports the results obtained with the Micro Probe, which allows the ciliary pars plicata to be observed and coagulated with ease.

EQUIPMENT AND METHODS

1. Equipment

The equipment used was the "Micro Probe" (Endo Optiks), which combines the functions of an endoscope and a semiconductor laser to allow intraocular observation and photocoagulation to be performed at the same time. It consists of a main console unit

Fig. 1 Endoscopic cyclophotocoagulation apparatus: the console

Kenji KAWAI, Ohgaki Municipal Hospital, 4-86 Minaminokawa-cho, Ohgaki, Gifu 503-8502, Japan

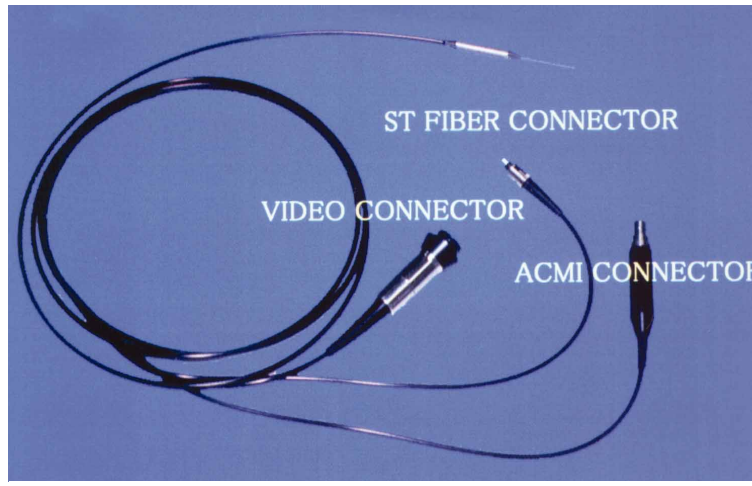

Fig. 2 Microendoscope: main body

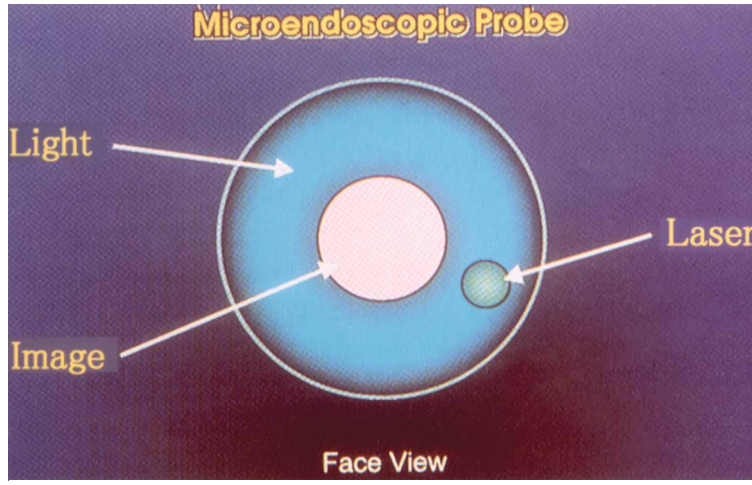

Fig. 3 Microendoscope probe: frontal view

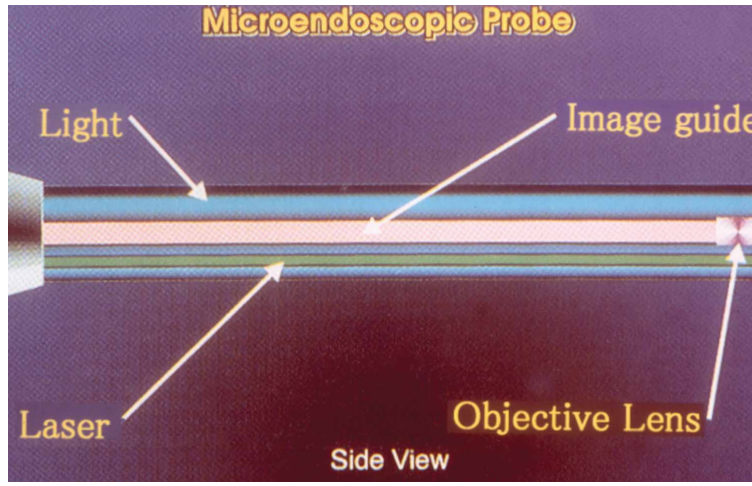

Fig. 4 Microendoscope probe: side view

Table 1 Specifications of this equipment

1) Laser wavelength	: Operating laser Semiconductor 810 nm
	Aiming laser Semiconductor 670 nm
Output	: Operating laser 0.01–1.20 W
	Aiming laser 1 mW or less
Irradiation time	: 0.05, 0.07, 0.10, 0.20, 0.30, 0.50, 1.0, 2.0 seconds, and continuous
Cooling	: Air system
(2) Light source	: Xenon lamp (175 W)
(3) CCD camera for observation:	Signaling system NTSC color
	Scanning system 525 lines, 2 : 1 interlace, 30 pieces per second
(4) Video monitor	: CRT (14 inches)
(5) Video recorder	: VHS system

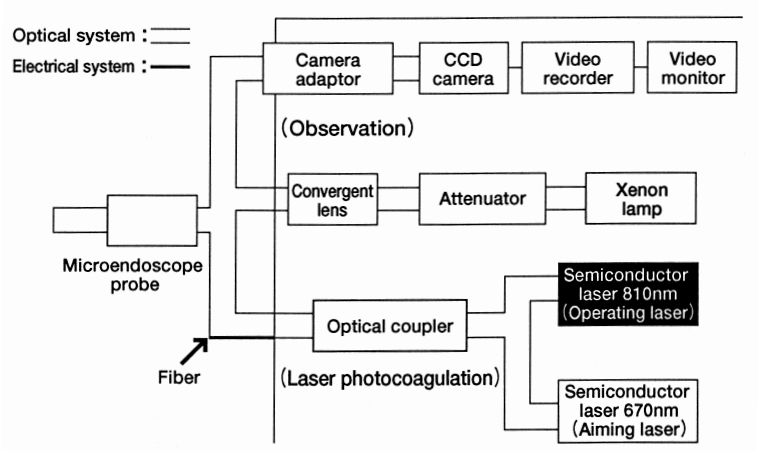

Fig. 5 Diagram of the equipment

(Fig. 1), a microendoscopic probe (Figs. 2 to 4), a foot switch, and a laser doctor filter. Table 1 lists the specifications: the laser wavelength was 810 nm for the surgical beam and 670 nm for the aiming beam, the output of the surgical beam ranged from 0.01 to 1.2 W, the irradiation time ranged from 0.05 seconds to continuous, and the laser unit was air-cooled. The light source was a xenon lamp of 175 W. Figure 5 shows a diagram of the equipment.

2. Animal experiment (Preliminary experiment)

An experiment was performed using porcine eyes to determine the visual performance and the safe coagulation conditions for the present equipment. Porcine eyes were cut horizontally along the equatorial plane and were placed in containers filled with water so that the ciliary body could be clearly observed with an endoscope. Coagulation was done with the laser set at an output of

Table 2 Coagulation condition, preoperative and final intraocular pressure, and visual acuity

Patient	Age	Irradiation output (mW)	Irradiation range (*)	Preoperative intraocular pressure	Final intraocular pressure	Preoperative visual acuity	Final visual acuity
1	62	400	120	39	21	Manual valve	0.04
2	54	300	120	40	26	0.03	0.01
3	59	400	180	46	55	0.02	Manual valve
4	63	350	90	42	19	Light-sensing valve	Manual valve
5	67	350	120	32	15	Manual valve	0.08
6	62	350	120	40	19	Manual valve	0.02

Table 3 Preoperative findings

Corneal edema/opacity	5 (83.3)
Vitreous hemorrhage	4 (66.7)
Pseudophakic eye	5 (83.3)
Aphakic eye	1 (16.7)
Silicone oil	1 (16.7)

Number of eyes (%)

Table 4 Perioperative and postoperative complications

Anterior chamber inflammation	6 (100)
Hyphema	1 (16.7)
Fibrin precipitates	0
Ophthalmalgia	0
Phthisis bulbi	0

Number of eyes (%)

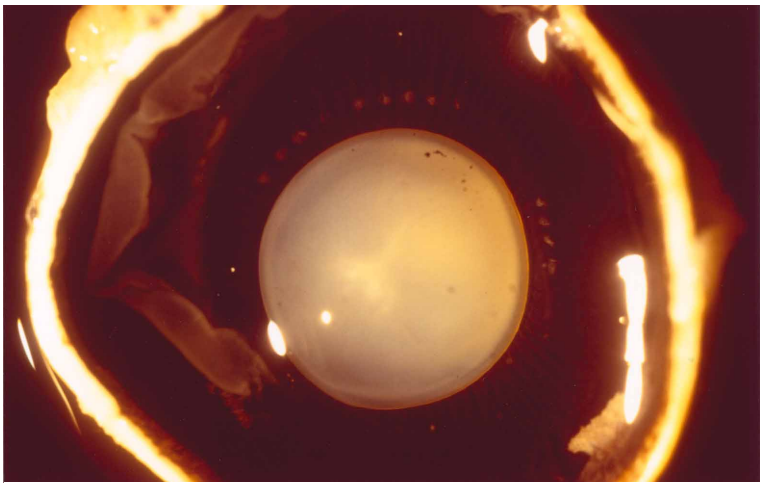

Fig. 6 Horizontal section of a porcine eye in the equatorial plane
White spots indicate the sites of coagulation.

300, 350, or 400 mW for 0.5 seconds. Then the eyeballs were fixed in 5% formaldehyde with 2.5% glutaraldehyde, dehydrated in an ethanol series, and embedded in paraffin. Finally, serial sections of the eyeballs were prepared and were stained with hematoxylin and eosin for light microscopy.

3. Subjects and methods

Six eyes were examined in six patients who had proliferative diabetic retinopathy complicated by neovascular glaucoma, which was resistant to pharmacotherapy and had become uncontrollable. Five of the 6 eyes had undergone vitreous surgery. All of the patients were women and their age

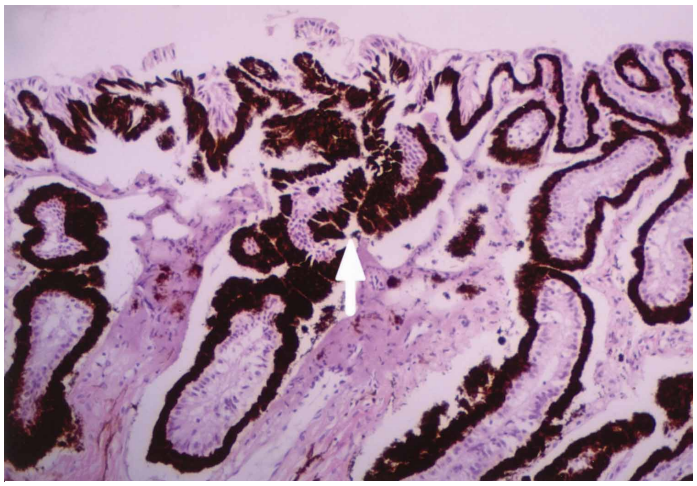

Fig. 7 Photomicrograph of tissue coagulated with the laser at an output of 400 mW and an irradiation time of 0.5 seconds (× 40)
The ciliary epithelium has been destroyed (arrow).

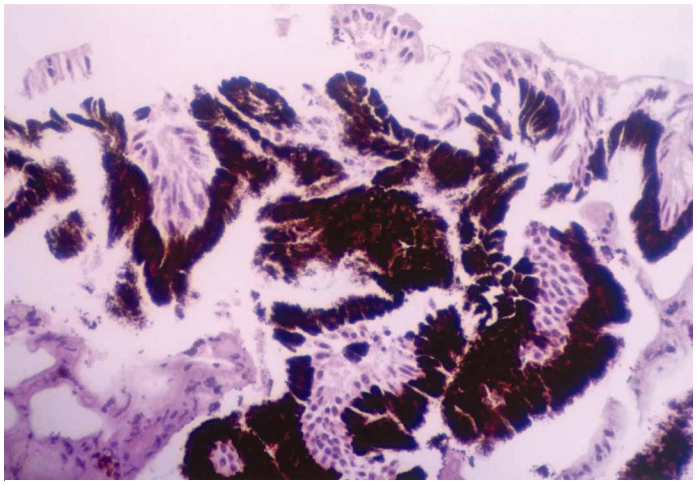

Fig. 8 Higher power view of the ciliary epithelium after laser treatment (× 80)

ranged from 54 to 67 years (mean: 61.2 ± 4.4 years). Preoperative intraocular pressure ranged from 32 to 46 mmHg (mean: 39.2 ± 5.0 mmHg). The subjects were followed for 8 weeks postoperatively (Table 2).

Preoperative findings included corneal edema or opacification in 5 subjects (83.3%) and vitreous hemorrhage in 4 (66.7%), as shown in Table 3.

All of the patients underwent the following surgical procedures under retrobulbar anesthesia: a scleral port was created to allow endoscopic resection of the vitreous body through the ciliary pars plana, the sclera was compressed with a cotton swab to confirm the ciliary pars plicata, and finally cyclophotocoagulation was performed. The coagulation conditions were an output of 300 to 400 mW, an irradiation time of 0.5 seconds, and an irradiation range of 90 to 180°. Atrophy and whitening of the ciliary processes was considered to be the end point.

RESULTS

1. Animal experiment (Preliminary experiment)

The whole ciliary body could be clearly viewed when the tip of the laser probe was

about 5 mm away from the tissue. However, the tip had to be moved closer (about 1 to 2 mm from the tissue) in order to cause whitening of the ciliary pars plicata (indicating coagulation) when the laser was used at an output of 0.3 to 0.4 W and an irradiation time of 0.5 seconds (Fig. 6). Figures 7 and 8 show hematoxylin and eosin-stained sections of the coagulated tissue. The ciliary body only showed damage to the epithelial layer, even at the site that was treated at 400 W, which caused the most pronounced coagulation. This confirmed that cyclophotocoagulation did not affect the muscular layer.

2. Clinical results

Cyclophotocoagulation could be easily performed in all of the patients (Figs. 9 and 10). Figure 11 shows the postoperative changes of the mean intraocular pressure: it was significantly reduced from 39.2 ± 5.0 mmHg preoperatively to 19.5 ± 3.8 mmHg at 8 weeks after surgery. Perioperative and postoperative complications included inflammation of the anterior chamber in 6 eyes (100%) and anterior chamber hemorrhage in 1 eye (16.7%). However, no fibrin deposits were observed, none of the patients experienced ocular pain, and phthisis bulbi did not occur (Table 4).

DISCUSSION

Recent advances in laser therapy [2–8] have led to the use of cyclophotocoagulation for the treatment of intractable glaucoma because the technique can be used to safely treat the ciliary body with minimum damage to the surrounding tissues. Laser therapy can be done in a trans-scleral [2, 4, 5, 8], intraocular [1, 3, 6, 7], or trans-pupillary manner. The trans-scleral technique involves the use of an Nd: YAG or semiconductor laser with a long wavelength of around 800 nm to reach the ciliary body. Oguri *et al.* [6] reported that the semiconductor laser produced fewer postoperative complications, including ocular pain and phthisis bulbi, when compared to the Nd: YAG laser. In contrast, Iijima *et al.* [9] performed a histopathological study showing that the semiconductor laser affected the sclera, ciliary parenchyma, and non-pigmented ciliary epithelial layer after experimental trans-scleral cyclophotocoagulation of rabbit eyes. These results indicate that trans-scleral cyclophotocoagulation with a semiconductor laser not only affects the ciliary epithelium, but also the surrounding tissues, although it causes fewer postoperative complications than conventional cryosurgery and cyclophotocoagulation with a Nd: YAG laser. Therefore, it has been hoped that a technique selectively targeting the ciliary epithelium will be developed for cyclodestructive surgery to reduce the production of aqueous humor.

Using the present combined semiconductor laser and endoscope [1, 7, 10], it was easy to coagulate the ciliary pars plicata under direct vision. This technique provided clear endoscopic images that allowed accurate coagulation based on appropriate control of the laser output. It also achieved its effect on the ciliary processes at a lower output because the laser light has a wavelength of 810 nm and penetrates the tissue further than the argon laser. In the preliminary experiments with isolated porcine eyes the laser neither caused coagulation nor destruction of the deep ciliary tissues, suggesting that this cyclophotocoagulation method may be less invasive, although interpretation of the histological changes is complicated by the fact that isolated, not living, eyes were tested. Trans-scleral cyclophotocoagulation has the disadvantage of inadequate or excessive coagulation leading to postoperative re-elevation of the intraocular pressure or phthisis bulbi, because the technique involves non-selective coagulation of the ciliary body. In contrast, the present method of cyclophotocoagulation allows better localization of the target tissues under direct vision.

Trans-scleral cyclophotocoagulation is technically easy and can be performed on an outpatient basis, while the present method is an intraocular procedure and therefore requires special care to prevent inflammation and postoperative infection associated with the scleral port for the laser probe. It also has the disadvantage that an approach from the ciliary pars plana is difficult in phakic eyes. It is possible to insert the probe under the iris from the corneal limbus to observe and coagulate the ciliary processes in phakic eyes after injecting hyaluronate sodium between the iris and lens to move the iris anteriorly [11, 12]. However, this may cause postoperative complications, including anterior chamber hemorrhage and lens damage, in patients with

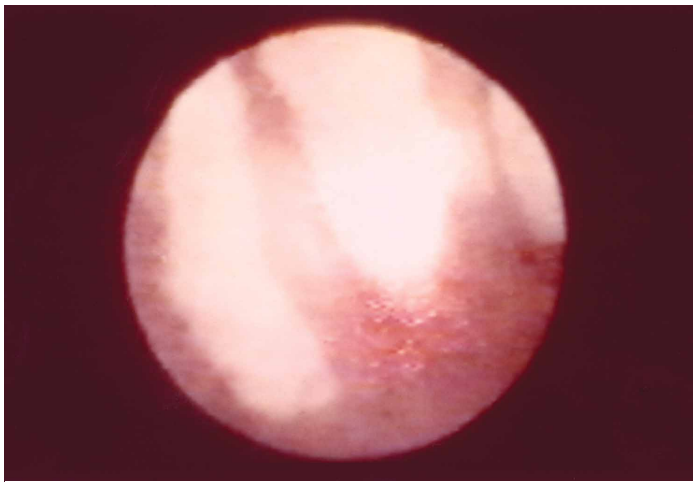

Fig. 9 Coagulation of the ciliary pars plicata

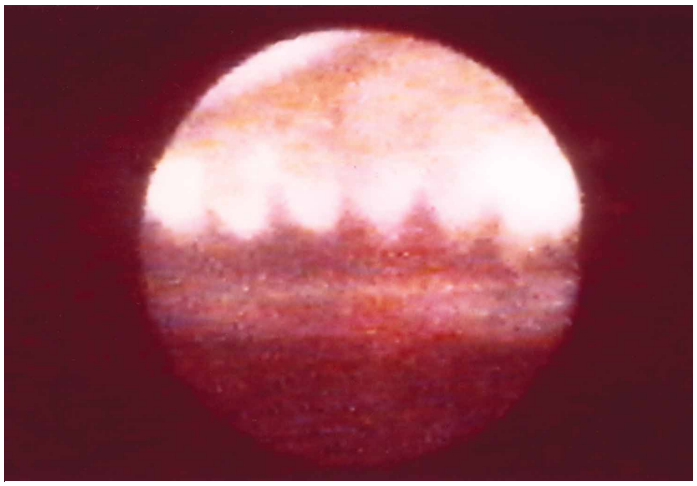

Fig. 10 General view of the ciliary body

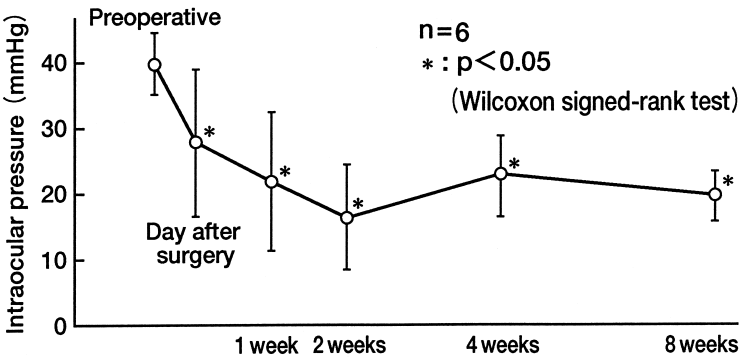

Fig. 11 Preoperative and postoperative intraocular pressure

extensive posterior synechia of the iris. It is therefore considered safe to perform cyclophotocoagulation with the present equipment via the pars plana approach in patients with an intraocular lens or aphakic eyes. Since the endoscope also allows surgeons to observe and coagulate the surrounding retina, it is probably best to perform this cyclophotocoagulation method in combination with vitreous surgery.

Filtration surgery combined with fibroblast growth inhibitors has recently achieved a dramatic increase in the success rate. However, the outcome for neovascular glaucoma has been poor compared with that for other types of glaucoma. It is difficult to maintain long-term filtration, especially in eyes that have undergone surgical treatment, because of extensive conjunctival scarring. All the present cases had extensive conjunctival scarring associated with previous vitreous or cataract surgery and required repeat vitreous surgery to treat recurrent vitreous hemorrhage. They were therefore considered to be indicated for endoscopic cyclophotocoagulation, which can be performed together with vitreous surgery and reduces the intraocular pressure without being influenced by conjunctival scarring. Cyclophotocoagulation could be performed in all of the patients in this series without serious complications, and there was a significant decrease of the intraocular pressure after surgery. These results confirm the initial safety and efficacy of the present cyclophotocoagulation method. Since cyclodestructive surgery may cause chronic complications, such as recurrence of ocular hypertension and phthisis bulbi, it is also necessary to examine the safety and efficacy of this method in a long-term study.

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