Argon indirect ophthalmoscopic photocoagulation: reduced potential phototoxicity with a fixed safety filter

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Abstract
A new argon indirect ophthalmoscopic photocoagulator is presented which uses a red helium-neon laser aiming beam. An interference filter protects the operator from green or blue-green treatment beam reflections without impairing visualisation of the aiming beam or significant retinal anatomy. The protective filter is fixed in place, eliminating the weight, noise, and potential failure of mechanically switched filters. The red aiming beam has a negligible potential for producing photochemical retinal damage in the patient or operator.

Binocular indirect ophthalmoscopic laser photocoagulation is useful for treating a variety of retinal disorders in the consulting room or operating room.1 Previously described laser indirect ophthalmoscopes (LIOs) have used the same wavelength for aiming and treatment beams and either a switched or fixed protective filter system.

Switched protective filters remain out of the operator's view during fundus and aiming beam observation.2 When the foot switch is depressed, they move into place, blocking treatment beam reflections. Switched filter systems provide unimpeded fundus observation, but they are heavy, noisy, and subject to mechanical failure, and the operator has no protection when viewing the aiming beam.

Fixed protective filter systems remain in place during observation and treatment.3-6 Since they have no moving parts, fixed filters are silent and intrinsically reliable. When aiming and treatment beams are of the same wavelength, however, a fixed filter may reduce the intensity of the observable aiming beam to an unsatisfactory level. Increasing the intensity of the aiming beam is a poor solution to this problem because it increases the patient's risk of iatrogenic thermal or photochemical retinal damage.

Since there are problems with both switched and fixed protective filters when a single wavelength is used for LIO aiming and treatment beams, we have helped to develop a dual wavelength LIO with a red (632.8 nm) He-Ne laser aiming beam and a green (514.5 nm) or blue green (488 nm +514.5 nm) argon laser treatment beam.

Material and methods
An argon laser console (Coherent Medical Division, Model 920/930) is attached by a primary fiberoptic cable to a coupler module. The module is attached by a secondary fiberoptic cable to an indirect ophthalmoscope (Keeler Instruments, Fison model with modifications). The module contains the ophthalmoscope's power supply and a 1 mW red He-Ne laser. The optical system is illustrated in Figure 1.

The coupler module combines aiming and treatment beams into a single coaxial beam that is focused into the secondary fiberoptic cable. The coaxial beam leaves the secondary fibre at the ophthalmoscope and is focused by a changeable objective lens before it reflects off a mirror. The operator directs the reflected beam into the patient's eye using a conventional aspheric ophthalmoscopic lens.

The user is protected from argon laser treatment beam reflections by an interference safety filter that blocks light between 455 nm and 525 nm. The safety filter transmits light at shorter and longer wavelengths to permit effective ophthalmoscopy and visualisation of the red aiming beam.

Figure 1: The dual wavelength indirect ophthalmoscope photocoagulator consists of an argon laser console, a coupler module, and an indirect ophthalmoscope. A primary fiberoptic cable attaches the argon laser console to the coupler module, and a secondary fiberoptic cable attaches the module to the ophthalmoscope. The coupler module contains the ophthalmoscope's power supply and a 1 mW red He-Ne laser. The module combines the aiming and treatment beams into a single coaxial beam that is focused into the secondary fiberoptic cable. The coaxial beam exits the secondary fibre at the ophthalmoscope and is focused by a changeable objective lens before it reflects off a mirror. The operator directs the reflected beam into the patient's eye with a standard aspheric ophthalmoscopic lens. The user is protected from argon laser treatment beam reflections by an interference safety filter that blocks light between 455 nm and 525 nm but transmits light at shorter and longer wavelengths to permit effective ophthalmoscopy and visualisation of the red aiming beam.
from the operator determined by the power of
the lens and the patient's eye. When the laser
beam is focused precisely at that distance, retinal
spot size is smallest and retinal irradiance is
highest. The dual wavelength LIO produces a
minimum retinal spot size of 320 μm with a 20-
dioptre ophthalmoscopic lens. Since deviations
as little as 50 mm from the focal plane of the
ophthalmoscopic lens can double the spot size
and reduce retinal irradiance by a factor of 4,
changeable objective lenses (320 mm, 420 mm,
and 520 mm focal lengths) are used to focus the
laser beam at the proper working distance for
different users. Deliberate deviation from the
focal plane is a useful method of increasing
retinal spot size.

Results
The dual wavelength LIO has the same uses as
those reported for single wavelength LIOs. In
the consulting room the LIO has been useful for
panretinal photocoagulation through vitreous
haemorrhage, for treating peripheral retinal
breaks, for photocoagulation following vitreo-
retinal surgery requiring intraocular gas, and for
treating patients whose frailty or obesity pre-
cludes conventional biomicroscopic photo-
coagulation. Additional operating room applica-
tions include photocoagulation in children under
general anaesthesia and retinopexy after
subretinal fluid drainage. With its built-in argon
filters, the LIO can also be used to direct retinal
endophotocoagulation when corneal or lenti-
cular opacities preclude safe treatment with an
argon laser beam originating outside the eye.

The fixed safety filter gives the fundus a
slightly yellowish tint but does not interfere with
the detection of fundus details such as small
retinal holes. The LIO is not useful for pro-
cedures such as macular photocoagulation that
require precision in burn placement, because
image magnification is too low and the patient's
or operator's head may move. If motion is
a problem in other procedures, decreasing the
duration of exposure and increasing laser power
can help limit size of burn, as can the use of
repetitive mode photocoagulation, which pro-
vides a series of burns with a single depression of
the foot switch.

Discussion
Clinical infrared laser systems generally use a
visible red He-Ne laser aiming beam. Since
infrared reflections can be blocked by a fixed
safety filter that does not impair visualisation of
the aiming beam or operating field, infrared laser
safety systems are usually silent, lightweight,
and intrinsically reliable. The safety system of
the dual wavelength argon LIO has these same
advantages. A similar system could be used with
conventional biomicroscopic argon photo-
coagulators.

The dual wavelength LIOs red He-Ne laser
aiming beam has the theoretical advantage of
lower light scattering and better penetration of
hazy ocular media than argon laser green or blue
green aiming beams. It has another possible
advantage unrelated to clinical applications.
Experimental studies have shown that suscepti-
bility to photic retinopathy increases with
decreasing wavelength: ultraviolet and blue light
have the greatest potential phototoxicity, while
red light has negligible damage potential. Studies
have also shown that phototoxicity may be
cumulative, so that light exposure increases the
risk of damage to subsequent light exposure.

In a conventional switched-filter LIO the user
is unprotected when viewing argon blue-green or
green aiming beam reflections. Furthermore,
intense aiming beams are often needed for treat-
ing hazy ocular media. A recent study has
demonstrated a subtle blue yellow colour
contrast defect in long-term argon photo-
coagulator operators. This defect is demon-
strable only with extremely sensitive com-
puterised testing, and its clinical significance is
uncertain. If the defect is significant, however,
the red aiming beam of the dual wavelength LIO
system has an additional theoretical advantage:
negligible potential retinal phototoxicity for the
patient and operator.

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M M Whitacre and M A Mainster do not have a proprietary
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