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Clinical Application of Monocular Indirect Argon Laser Photocoagulator

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The monocular indirect argon laser photocoagulator has been newly developed through NIDEK CO. LTD, Japan. This instrument consists of a monocular indirect ophthalmoscopic delivery system, a beam control box, a standard slit-lamp delivery system and a changeover switch. The characteristics of this photocoagulator are as follows: a easier application, better viewing of whole fundus during retinal photocoagulation, effective photocoagulation in supine position, posibility to change direct photocoagulator or indirect one by the changeover switch and photocoagulation viewed from all directions around the patient head.

After confirming the condition and safety by experimenting on rabbits eyes, laser photocoagulation is to be performed on diabetic retinopathy, retinal tear, branch occlusion of retinal vein, retinal neovascularization, retinal macroaneurysm and retinopathy of prematurity. Especially this monocular indirect argon laser photocoagulation can be applied more effectively than xenon light coagulation on the retinopathy of prematurity thanks to overall view of the fundus in supine position. While on the other hand it has two unfavorable points, i.e. it is unstable to be fixed and that fine and delicate laser photocoagulation in the macular area cannot be performed. So it is preferable to use it combinatively with a slit-lamp type by changeover switch, depending on the conditions of the fundus.

INTRODUCTION

The first laser was built by MAIMAN in 1960. This successful irradiation of laser ray brought the new laser therapy into the medical field. In the field of ophthalmology photocoagulation treatment by Xenon which was developed by MEYER-SCHWICKERATH had been widely prevailed since 1956, and for that reason laser was intro-
duced without much opposition into the field of ophthalmology as an excellent light source.

Now various types of laser rays are being developed as therapeutical method in the medical field, while in the ophthalmological territory, Ruby, Argon, Krypton, CO₂ and Dye lasers have been put into tests, and Ruby (pulse, continuous ray, Q-switch), Argon (continuous ray) and Krypton (continuous ray) laser are now in practical use. Slit lamp type argon laser photocoagulator (hereinafter called slit lamp type) is now most widely used. In 1981, MIZUNO³ developed the new binocular indirect argon laser photocoagulator (hereinafter called indirect binocular type) in order to make up for the imperfection of the slit lamp type. MIZUNO noted the weak points of slit lamp type as follows:

1) observation and photocoagulation through Goldmann 3 mirror contact lens is difficult and an overall view of the fundus may be missed.
2) it is difficult to coagulate dead areas with the Goldmann 3 mirror lens, because of dead angle spreading from 20° to 40° degrees.
3) it is impossible to coagulate patient’s eye in the supine position.
4) binocular observation of peripheral fundus through the Goldmann 3 mirror lens is more difficult even with use of a depresser.
5) patients have to endure immobile posture during operation, occasionally for a long time.

To overcome these problems MIZUNO³ devised a new delivery system of the argon laser beam. He appreciates the advantage of the binocular indirect type that enables one to get an overall view of the fundus in supine position, although there might be a slight instability in aiming.

MIZUNO⁴ has also developed through NIDEK CO, LTD, Japan, a new dual purpose argon laser photocoagulator which enables practitioners to operate photocoagulation by either binocular indirect ophthalmoscope and or slit lamp by change over of switch.

In Japan, however, the monocular indirect ophthalmoscope is used mainly in practice, for that reason a new type of photocoagulator adopting monocular indirect ophthalmoscope was designed by NIDEK CO, LTD, Japan. In comparison with the binocular ophthalmoscope type the monocular type is more familiar, less fatigue and more efficient, although it is a little bit inconvenient to use, i. e. one hand is always occupied. This report is describes the management and results of this indirect monocular argon laser photocoagulator.

MATERIALS AND METHODS

Instrument: This monocular indirect ophthalmoscope type argon laser photocoagulator is to replace the indirect binocular ophthalmoscope by MIZUNO with a monocular indirect ophthalmoscope. However, from the standpoint of the structure there are some differences, i. e. the binocular type is equipped with a foot switch, manual block-in filter and coaxial beam, while the monocular type has manual switch, automatic block-in filter
and non-coaxial beam.

It is the advantage of the monocular type that the hand switch and blocking filter work synchronously in comparison with the binocular type.

This new instrument consists of: Laser unit, Control unit, Fiber optics, Slit lamp for observation and coagulation, Monocular indirect ophthalmoscope for observation and coagulation and Changeover switch (Figure 1).

The principle wave lengths in this argon laser are 488 and 514.5 nm, output during aiming is less than 1.2 mw on cornea and output during aiming coagulation is 0.03 to 1.50 W on cornea. The laser spot sizes are shown by 4 steps, i. e. 150, 300, 600 and 1000 micron and coagulating time are shown by 10 steps, i. e. 0.02, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.7, 1.0 and 3.0 sec., and can be displayed digitally on the control box. The approximate weight of indirect ophthalmoscope is about 500 gm.

Illuminating light emanating from 150 W halogen lamp which is set inside the console box, is guided into the indirect ophthalmoscope through glass fiber of 3 mm diameter. Laser beam is guided into the same indirect ophthalmoscope through the quartz fiber of 80 micron diameter. These two fibers are gathered into one cord of 1.2 cm diameter and is kept into the indirect ophthalmoscope. From the ophthalmoscope

Figure 1. Monocular indirect argon laser photocoagulator
1. Console Box of Laser Unit
2. Control Unit
3. Fiber Optics
4. Slit lamp for Observation and Coagulation
5. Monocular indirect Ophthalmoscope for Observation and Coagulation
6. Changeover Switch
respective beams can be emitted into the eye by reflective mirrors with different angles. This optical system is so designed that the laser beam is emitted on fundus maintaining the accurate center of the ray bundle. The blocking filter to protect surgeon is kept inside the scope and is so designed that it blocks optical path simultaneously when the trigger which is located underneath the ophthalmoscope grip is pushed.

Operating technique: When observing the fundus it is recommended to use a hand-held lens of 20 diopters and this ophthalmoscope is so designed that to make image formation of spot size on fundus when the distance between the ophthalmoscope and hand-held lens is kept at 30 cm. That image is focused when the spot size is at 150 microns and in other distances spot sizes can be changed but not to be focused.

Figure 2. Diagram of the Optical System of the Monocular Indirect Argon Laser Photocoagulator
1. Quartz fiber for laser
2. Spot size setting lens
3. Projection lens
4. Mirror
5. Hand lens
6. Patient's eye
7. Illuminating lamp
8. Glass fiber for illumination
9. Condenser lens
10. Prism
11. Operator's eye
12. Protection filter
Figure 3. Monocular indirect argon laser photocoagulator in operation keeping 30 cm distance.

Figure 4. 1. Monocular indirect ophthalmoscopic photocoagulator (arrow trigger)  
2. String with knotted point for keeping distance  
3. 20 diopter lens
In the handing of the monocular indirect argon laser photocoagulator the surgeon has to hold a 20 diopter convex lens in one hand, and grasps the ophthalmoscope in the other hand while putting the forefinger on the trigger switch lightly (Figure 3). On keeping 30 cm distance between the ophthalmoscope and 20 diopter lens it is better to put a ring on surgeon’s thumb and to hold the ophthalmoscope at the 30 cm knotted point of string with a ring at the end and treat coagulation (Figure 4). This might not always be an accurate 30 cm but by this method discrepancy of distance can be checked during operation and it serves to reduce case of missing coagulation. Induce the green aiming beam to the diseased part, take aim, and then push the trigger. Spot size and coagulating time should be preliminarily fixed and raise power until satisfactory coagulating spot can be obtained. When a contact lens is not used it is necessary to drop saline solution lest cornea should dry up.

To change from slit lamp type to monocular indirect ophthalmoscope type is only to switch the changeover switch, then spot size display only of control unit will disappear, but digital displays of time, output power and number of coagulation will not be changed at all.

As to preoperative arrangement, patient’s eye should be anesthetized with 0.4 % oxybuprocaine and dilated pupil completely with Mydrin P (0.5 % tropicamide and 0.5 % phenylephrine solution).

All patients are to be placed in a supine position and a blepharostat was inserted and then a hard contact lens of 11 mm diameter be put on the cornea to prevent it from drying. Inside the contact lens one drop of Scopizol should be lubricated beforehand.

Problem of operation: The key points of photocoagulation are output power and focusing, especially in indirect ophthalmoscope photocoagulation (either binocular or monocular) focusing is most important and difficult problems. This might become causes of coagulation loss in connection with the problem of output power. This is also the weakpoint of ophthalmoscopic photocoagulation.

Shaking of lens and ophthalmoscope will make deformation of coagulating spots and in case of coagulation of peripheral retina spot size is liable to be enlarged, and care should be taken last surgeon should miss coagulation by reflection and deformation of cornea, reduction of observation area, which make aiming beam difficult to be observed. Drying up and opaqueness of cornea could be prevented by using a contact lens which makes treatment feasible. But in coagulation of peripheral area when contact lens will disturb observation by slipping off, it is recommended to remove contact lens and to drop saline solution on the cornea.

RESULTS

At first practice eye models are to be used for treatment and coagulation tests, and after that mature colored rabbit’s eyes should be used and coagulated experimentally on the following conditions:
1) Ophthalmoscopic lenses, +14 D, +20 D, +28 D.
2) Distances between ophthalmoscopic lens and ophthalmoscope, 20 cm, 30 cm, 40 cm.
3) Spot sizes, 150, 300, 600, 1000 micron.

By various combinations of the above mentioned conditions the most suitable coagulating output should be examined. Time treated is to be set 0.1 second to avoid shaking of aiming beam. As the most reasonable output power it should be adopted that yielded white grey coagulating spot in 1/2 to 2/3 sizes of original spot size right after the respective coagulation. Table 1 shows the relations between various conditions as above and inferred the results thereof as follows:

1) In the distances between the lens and ophthalmoscope of 20 cm and 30 cm on any lenses, the larger the spot sizes are, the more power output is required. In case of 40 cm, the smaller the spot sizes are, the more power output is required.
2) In 28 diopter lens the results are the same as above, but in this case more power output is required than in case of 14 diopter and 20 diopter.

Clinical applications: As MIZUNO stated before that due to instability of aiming light, precise coagulation on macular area should be prohibited. And therefore, straight coagulation for macular neovascularization and central serious choroidopathy should be avoided. Coagulation in the seated position of surgeon might prevent shaking during

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C 150 um</th>
<th>C 300 um</th>
<th>C 600 um</th>
<th>C 1000 um</th>
</tr>
</thead>
<tbody>
<tr>
<td>+14 D</td>
<td>20 cm</td>
<td>0.1 w</td>
<td>0.15 w</td>
<td>0.2 w</td>
<td>0.35 w</td>
</tr>
<tr>
<td></td>
<td>30 cm</td>
<td>0.05 w</td>
<td>0.1 w</td>
<td>0.1 w</td>
<td>0.2 w</td>
</tr>
<tr>
<td></td>
<td>40 cm</td>
<td>0.3 w</td>
<td>0.2 w</td>
<td>0.1 w</td>
<td>0.1 w</td>
</tr>
<tr>
<td>+20 D</td>
<td>20 cm</td>
<td>0.1 w</td>
<td>0.15 w</td>
<td>0.25 w</td>
<td>0.5 w</td>
</tr>
<tr>
<td></td>
<td>30 cm</td>
<td>0.1 w</td>
<td>0.1 w</td>
<td>0.15 w</td>
<td>0.25 w</td>
</tr>
<tr>
<td></td>
<td>40 cm</td>
<td>0.35 w</td>
<td>0.25 w</td>
<td>0.15 w</td>
<td>0.1 w</td>
</tr>
<tr>
<td>+ 28D</td>
<td>20 cm</td>
<td>0.1 w</td>
<td>0.1 w</td>
<td>0.35 w</td>
<td>0.6 w</td>
</tr>
<tr>
<td></td>
<td>30 cm</td>
<td>0.1 w</td>
<td>0.1 w</td>
<td>0.15 w</td>
<td>0.4 w</td>
</tr>
<tr>
<td></td>
<td>40 cm</td>
<td>0.55 w</td>
<td>0.45 w</td>
<td>0.15 w</td>
<td>0.1 w</td>
</tr>
</tbody>
</table>

A: Ophthalmoscopic Lens
B: Distance between Lens & Ophthalmoscope
C: Spot size
Figure 5. Pan photocoagulation in a patient with proliferative diabetic retinopathy

Figure 6. After photocoagulation of the branch occlusion of retinal vein.
coagulation, but in order to minimize shaking during coagulation operation for not more than 0.1 second is required. Output power should be adjusted according to coagulation spot obtained.

As shown in Table 2, the cases treated by the monocular indirect argon laser photocoagulator were mostly on diabetic retinopathy (Figure 5.) and also included branch occlusion of the retinal vein (Figure 6.), retinal neovascularization, COATS' disease, retinal macroaneurysm, retinal tear without retinal detachment and retinopathy of prematurity. Some of them were treated together by slit lamp type. The retinopathy of prematurity can be operated more freely under an overall view of the fundus in supine position than Xenon light coagulation. However, it was a problem that aiming beam was unstable due to movement of baby's head. Three baby's eyes were treated with coagulations of 600 micron at power level 250 to 300 mW for 0.1 sec. exposures. In other cases there were no problems worth mentioning.

### Table 2. The Cases treated by the Monocular Indirect Argon Laser Photocoagulator (Nov. 1, 1981 to Feb. 28, 1983)

<table>
<thead>
<tr>
<th>Eye</th>
<th>No. of</th>
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<tr>
<td>Diabetic retinopathy</td>
<td>70</td>
</tr>
<tr>
<td>Retinal tear</td>
<td>4</td>
</tr>
<tr>
<td>Retinopathy of prematurity</td>
<td>3</td>
</tr>
<tr>
<td>Branch occlusion of retinal vein</td>
<td>2</td>
</tr>
<tr>
<td>Coats' disease</td>
<td>1</td>
</tr>
<tr>
<td>Retinal macroaneurysm</td>
<td>1</td>
</tr>
<tr>
<td>Retinal neovascularization</td>
<td>1</td>
</tr>
</tbody>
</table>

DISCUSSION

MIZUNO\(^3\) described the advantages of the operation of the binocular indirect argon laser photocoagulator as follows:
1) Saving of times for photocoagulation.
2) More comfortable treatment in supine position.
3) Freedom for application of the laser beam to the central area and to the peripheral retina.
4) Scanning the whole fundus during photocoagulation possible and confirmation of localized pathological changes which require treatment, possible.
5) Panphotocoagulation of the fundus under stereoscopic visualization, possible.
6) Management after retinal detachment surgery inside or outside the operating room, possible.

These advantages are same in the monocular indirect type except stereoscopic visualization but the handling is more free in monocular type than in binocular type. But the above mentioned advantages are more than enough to make up for the weak point of hand shaking when aiming. Thanks to convertibility of multi-purpose type by only changeover switch, the slit lamp type can also be used when required, and by using the one together with the other any surgeon can attain his object. As to emission system, there is still room for further investigation about which is better, i.e. the trigger of the...
foot switch or hand switch. From the point of view of mitigating shaking of ophthalmoscope, the latter may be possible better. When comparing with binocular ophthalmoscope type and the monocular type, the former has the advantage of one hand being unoccupied, but in practical use, monocular type, with which most doctors are familiar, might be more convenient and adoptable and has more possibility to be operated for a long time without fatigue.

REFERENCES