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New Instruments

OMNIDIRECTIONAL ILLUMINATION LIGHT SOURCE DEVICE

LED ORB Light System

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Three-port 20-gauge (20 G) vitreous surgery, first reported by O'Malley et al[1] in 1975, marked the beginning of the development of vitrectomy procedures. Subsequently, 25 G[2] and 23 G[3] microincision vitrectomy surgery was described. Despite facing challenges such as an initial lack of suitable instruments (e.g., insufficient instrument strength and poor suction excision efficiency), Oshima et al[4] made impressive progress and, in 2010, described 27 G microincision vitrectomy surgery, which is now recognized as a minimally invasive vitreous surgical technique. At the same time, observation systems have changed. Wide-angle observation systems such as the BIOM (Oculus),[5] OFFICE (TOPCON),[6] and Resight (Zeiss)[7] have been developed. Vitreous surgery using a wide-angle observation system and microincision vitrectomy surgery is now mainstream practice.

However, the advantages of wide-angle observation are limited at present because conventional probes use chandelier light sources, and it is impossible to illuminate the entire fundus with a single chandelier fiber because the irradiation angle is narrower than the observable range of the wide-angle observation system. The surgeon is forced to control the fiber, change its position during surgery, or place two fibers to illuminate the surgical field.

In this article, we describe the LED ORB light system (Nutraceuticals Inc), which we have developed. This system can eliminate the difficulties faced with a conventional chandelier light source because its illumination angle of 360° can illuminate the entire fundus using a single fiber.

Methods

The ORB light system is composed of an ORB-500 light-emitting diode (LED) light source and a light guide fiber. The light source is a small surface mount LED that emits bright (320,000 ×l) white light (6000 K). Light-condensing technology provides a narrow beam angle (≤2°) for efficiently guiding the ultrafine fiber (400 μm diameter at 25 G; 250 μm at 27 G), giving compact, long-life, low-cost and highly efficient light. The surface mount LED is considerably more compact and lighter in weight than a conventional chandelier light source device, the super-high-performance versions that typically have a light intensity adjustment dial with values from 1 to 10, an outer diameter (excluding protrusions) of 300 mm, height of 69.5 mm, depth of 200 mm, and weight of 1.47 kg (Figure 1A).

There are two types of light guide fiber, F-500 (25 G) and F-700 (27 G). They are made of plastic optical fiber with a total length of 2,000 mm and insertion length of 100 mm. A diffuser is attached to the end of the fiber to diffuse the light, enabling 360° illumination. A stopper and light-shielding sleeve are also included (Figure 1, B and C). When we connected the F-500 (25 G) fiber to the ORB-500 and measured the radiated light at maximum power, the color temperature was 4,800 to 5,900 K and the illuminance

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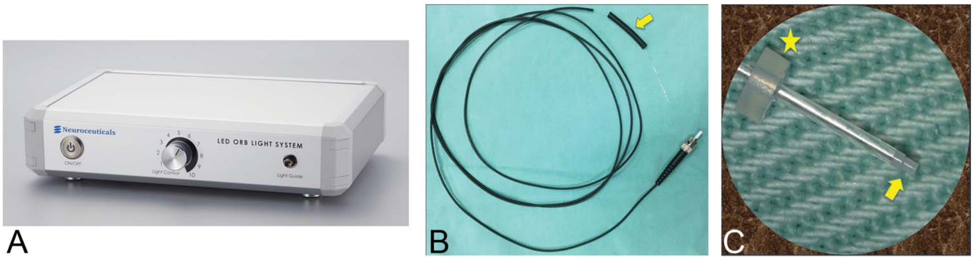

Fig. 1. LED ORB light. **A.** ORB-500 body. **B.** ORB fiber F-500 whole view (arrow: light-shielding sleeve) and (**C**) F-500 tip (asterisk: stopper; arrow: diffuser).

about 6,500 lx. With the F-700 (27 G) fiber, illuminance was 4,000 ×l, which is sufficient for surgery. Retinal phototoxicity limits were not reached until about 3 hours of vitreous surgery. Currently, the ORB light system is only available in Japan; however, it will be marketed overseas once the Food and Drug Administration has granted approval and the European Union has approved CE marking.

Results

All areas in the fundus were evenly illuminated by a single fiber. This eliminated the need for any complicated manipulations to illuminate the target site during surgery, change the arrangement of light source fibers, or use two fibers, as would be expected when using a traditional chandelier light source. The observation image was as good as when illuminated by a white fluorescent lamp. Observation was good during normal intraoperative procedures for vitrectomy, membrane treatment, intraocular laser surgery, and fluid–gas exchange.

To ensure good illumination, the entire diffuser at the tip of the light guide fiber must be inserted into the eye. For this reason, a cannula is attached to the fiber in advance so that only the diffuser is exposed to the eye, and the stopper is adjusted at the diffuser exposure position. A cannula is inserted in the meridian direction, the fiber is inserted into the cannula, and the cannula is then withdrawn about 2 mm to avoid microscopic backlighting, improve microscopic observation, and facilitate removal of the peripheral vitreous. The light-shielding sleeve covers the entire cannula valve to avoid difficulties in microscopic observation caused by the scattered light from the fiber.

Under the microscope, the inside of the eye can be observed by continuous endoillumination. As a result, the operating field is wide and easily navigated, making intraoperative maneuvers safer. In addition, suction and resection can be performed with a cutter immediately after membrane peeling (Figure 2).

Under conventional endoscopic observation, the probe had to be moved to the optimal observation site because of the low intensity of the light source, as well as the lower image quality and limited observable portion because of its narrow viewing angle. However, the ORB light system enables 360° illumination of the fundus and a good endoscopic image by inserting only the endoscope probe into the eye, even with the conventional endoscope light source turned off. Therefore, even beginners can easily navigate the fundus. In addition, resection can be performed very close to the retina because the shadow of the cutter tip in the ORB light system makes it easy to determine the distance to the target (Figure 3, see **Video, Supplemental Digital Content 1**, http://links.lww.com/IAE/B367). The clinical use of this device was in full compliance with the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board/Ethics Committee of Center Organization for Clinical Trials, Miyazaki Medical Association (2020-01).

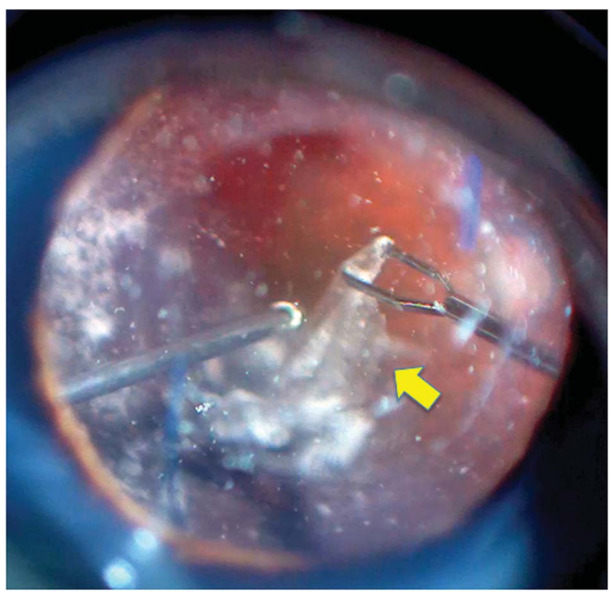

Fig. 2. Microscopic image of bimanual peeling of the epiretinal membrane. Suction and resection are performed at the same time as membrane peeling (arrow: peeled membrane).

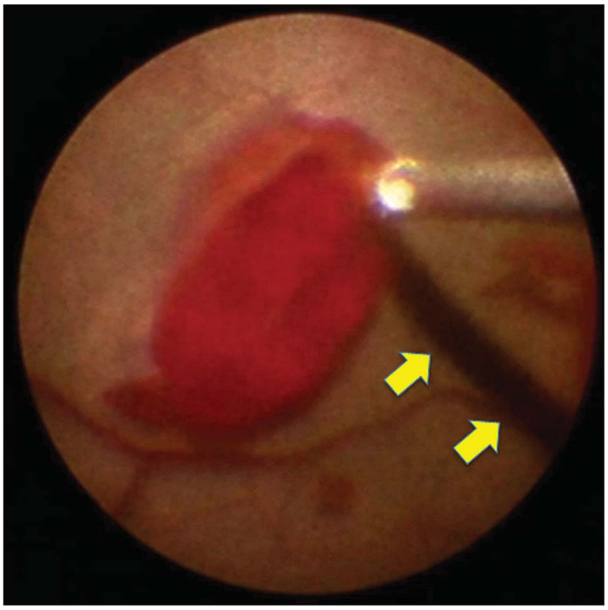

Fig. 3. Endoscopic image of resection and suction of bleeding close to the retina. The cutter tip does not touch the retina, despite closely approaching it, because the shadow of the cutter tip (arrow) in the ORB light system enables the distance to the target to be easily determined.

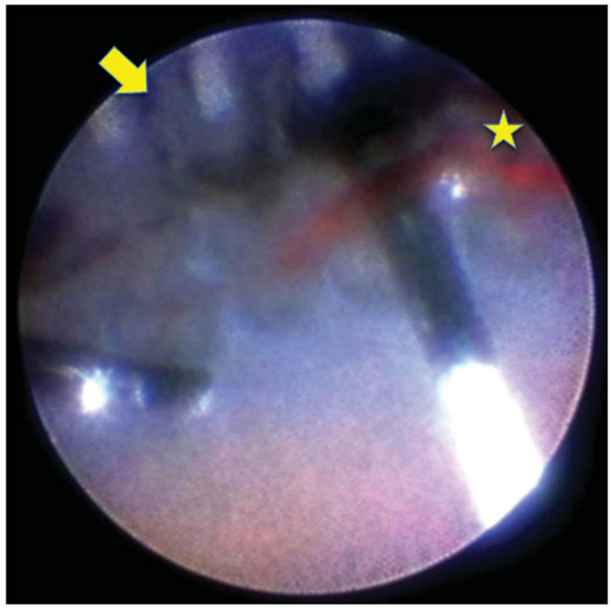

Fig. 4. Endoscopic image of treatment of vitreous hemorrhage at the site of insertion of the ORB fiber. Treatment of vitreous hemorrhage from the pars plana, ora serrata, and ciliary folds. Vitrectomy was performed at the cannula insertion site (asterisk: vitreous hemorrhage; arrow: ciliary folds).

Discussion

Various light sources have been used for intraocular illumination. Halogen was the most popular light source in the 20 G vitreous surgery era, but it gives out a weak and yellowish light. Later, xenon light sources were used, which provide sufficiently strong white light, but various filters have to be used to avoid retinal phototoxicity. Xenon light also comes with other problems, such as a short lifespan. Mercury vapor lamps are another option, but environmental considerations prohibit their widespread use. In 2010, the LEDStar (DORC Inc) was released, which used an LED light source. Today, LEDs are the mainstream choice of light source, owing to their long life, low price, small size, low heat generation, and many other advantages. However, with chandelier fibers, the irradiation angle is limited to 180°, making it impossible to illuminate the whole fundus with one fiber.

The ORB light system scatters the light 360° by modifying a surface mount LED so that light can be efficiently introduced into the fiber, ensuring sufficient light, and then installing a specially processed diffuser at the fiber tip. This makes it possible to observe the entire intraocular area at all times during surgery. Coupled with a wide-angle observation system, the system allows a wide view of the entire intraocular lesion during microscopic surgery. Furthermore, it allows more delicate operations that require bimanual maneuvers, as in general surgery. In endoscopic surgery, the ORB light system enables better endoscopic images to be obtained than using conventional endoscopy because the amount of light is so much greater than that from the light guide in the conventional probe. This makes it easier to treat vitreous hemorrhage from the pars plana, ora serrata, and ciliary folds, and vitrectomy at the cannula insertion site is also easier to perform (Figure 4, see **Video, Supplemental Digital Content 2**, http://links.lww.com/IAE/B368).

We believe that the ORB light system will be useful as a light source device for surgeons because it enables the whole fundus to be viewed. Furthermore, we think that it will expand the possibilities of heads-up surgery,[8] intraoperative optical coherence tomography,[9] and vitreous surgery techniques that are currently being developed.

Key Words: Omnidirectional illumination light, source device, LED, ORB light system..

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