• Letter to the Editor •

A simple, low-cost 3D printed adaptor for endoillumination in intraocular surgery

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Dear Editor,

The application of three-dimensional (3D) printing techniques in ophthalmology enables cost-effective design and production of custom medical instruments[1-2].

Complications of cataract surgery, such as a dropped nucleus, cortex, or intraocular lens, may require vitreoretinal surgery[3]. Although there is a vitrectomy port in most phacoemulsification machines, endoillumination is not available[4]. There are some external light source devices such as Photon (Synergetics), Xenotron III (Geuder) and Bright Star (DORC), but they are expensive and may not be available in all hospitals. This study was approved by the Institutional Review Board of Joint Shantou International Eye Center.

We developed a 3D printed adaptor that connects a LED flashlight to an Alcon 23-gauge fiber (Figure 1A and Video 1, online supplementary). The adaptor was designed using the 3D Builder software (version 18.0.1931.0, Microsoft Corp.) which is a free Windows app. The adaptor is fashioned using two hollow cylinders on top of each other with the same external diameter but different internal diameter. The external diameter of the adaptor is consistent with the internal diameter of the flashlight, so that the adaptor fits well in the flashlight. The upper hollow cylinder with a smaller internal diameter matched with the external diameter of the fiber. The inferior hollow cylinder with a larger internal diameter serves as a light channel (Figure 1B). The diameter can be modified according to the model of the flashlight and the fiber. The adaptor was printed using a Fused Deposition Modelin 3D printer, da Vinci nano (XYZ Printing, Suzhou, China; Figure 1C). The cost of 3D printing material was less than 1 USD, and the time spent was less than 2h. The cost of the 3D printer is 150 USD. It can also be printed using an online service. A 50 W LED flashlight was purchased from an online shopping website, Taobao (https://item.taobao.com/item.htm?spm=a1z0d.6639537.1997196601.4.76ed74846RJdsb&id=625303655848), with a price of 78 CNY (12 USD). The cost of the entire device is affordable, even in rural regions where this device is most in need.

We measured the brightness of the 23-gauge fiber connected with our 3D-printed adaptor/flashlight and the xenon lamp on the Alcon Constellation machine using a spectrometer (Hopoocolar OHSP-350, China). The tip of the 23-gauge fiber was positioned at 10 mm above the spectrometer in a dark room. The luminance of our adaptor/flashlight was 7468 lx. It was higher than 20% illuminator setting of the Alcon Constellation (7059 lx), which is the typical setting in our routine operations (Figure 1D). We also used this device in real surgery. The view was bright and clear during vitreoretinal operations (Figure 1E).

The irradiance of the adaptor and the Constellation was also measured using the spectrometer (Table 1). The irradiance of the adaptor at 305-400 nm was between 10%-20% luminosity of Constellation. While the irradiance of the adaptor at 305-700 nm was at between 20%-30% luminosity of Constellation. Based on these data, the irradiance safety of our adaptor/flashlight is comparable with the common setting on Constellation illuminator.

The applications of this device is not only for the management of complications of cataract surgery but also other vitreoretinal surgeries performed using the cataract machine[4]. It can also be used in some cases where the xenon lamp of the vitrectomy machine is broken. Besides the cost, our device also has the advantage of small size compared to the current commercially available external light sources (Figure 1F).

We encourage the use of this device as an emergency tool when a traditional light source is not working during vitrectomy. Moreover, some cataract surgeons are not well-

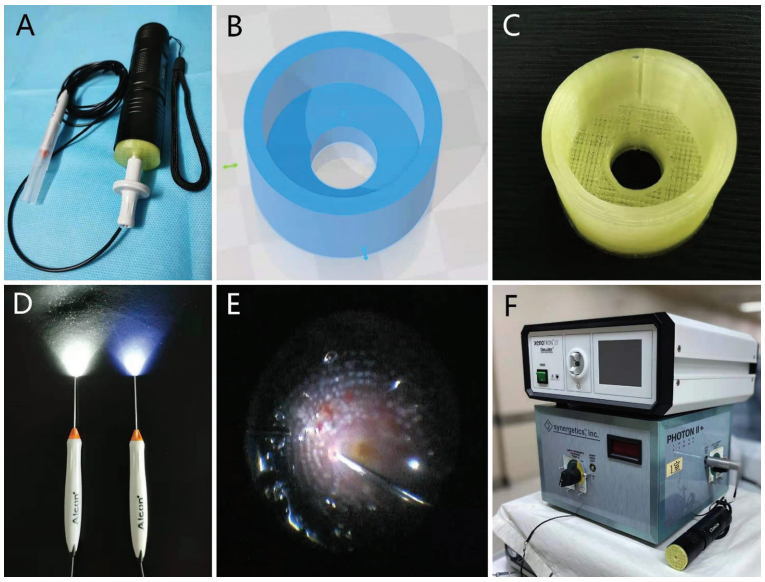

Figure 1 A 3D printed adaptor for endoillumination A: The adaptor connects a flashlight and an Alcon fiber; B: Design of the 3D model of the adaptor in the 3D Builder software; C: The adaptor printed using a Fused Deposition Modelin 3D printer, da Vinci nano; D: Comparison of the brightness of the fibers connected to the adaptor/flashlight (right) and Alcon Constellation (left); E: Snapshot of a vitreoretinal operation endoilluminated by the 3D printed adaptor and flashlight; F: Comparison of the size of three external light sources, Xenotron III (Geuder), Photon II (Synergetics), and the flashlight/adaptor.

Table 1 Comparison of irradiance of the adaptor with those of Xenotron III and constellation

Range of wavelength (nm)	Distance (mm)	Irradiance of constellation with various luminosity (mW/cm^2)				Irradiance of the adaptor with flashlight (mW/cm^2)
		10%	20%	30%	40%	
305-400	5	0.0041	0.0096	0.0226	0.0323	0.0048
	10	0.0020	0.0039	0.0106	0.0154	0.0024
	15	0.0009	0.0024	0.0055	0.0080	0.0011
305-700	5	1.1783	5.7662	10.3995	19.1964	9.8837
	10	0.5271	2.0329	5.0633	7.9528	2.6075
	15	0.1560	1.0641	2.5001	4.2941	0.9743

trained vitreoretinal ones and it is better to close the eye and refer more than try to do something without the specific skills. Overall, our 3D printed adaptor with a LED flashlight provides a simple, low-cost, efficiency and safe light source for endoillumination of intraocular surgery.

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