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Google Cardboard Indirect Ophthalmoscopy

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Summary

We describe the use of Google Cardboard for indirect ophthalmoscopy without dedicated ophthalmic equipment and with minimal cost. A smartphone is loaded with the camera and light extruding laterally, and the image centered on the examiner's dominant eye. The second acrylic lens, measuring approximately 22D, serves as an indirect lens.

Keywords

Google Cardboard; indirect ophthalmoscopy; retinal imaging

INTRODUCTION

Indirect ophthalmoscopy is an essential component of intraocular examination. It depends on a nearly-parallel head-mounted light source and prisms to provide a view of the retina and optic nerve to the examiner.

Infrastructure limitations prevent indirect ophthalmoscopy in much of the developing world. Power outages contribute to inadequate electrical supply. Corrosion of circuitry secondary to environmental exposure may prevent long-term use of headsets.

Smartphone-based ophthalmoscopy allows recording of fundus examinations, uses a rechargeable, battery-powered light source directly next to the smartphone camera, and requires only the addition of a lens. We have previously described the use of Google Glass for indirect ophthalmoscopy,¹ but this device most recently cost \$1500 and is no longer commercially available.

In June 2014, Google (Mountain View, California, United States) publicly released production details for Google Cardboard, a do-it-yourself toolkit with the purpose of producing a basic virtual-reality platform out of common smartphones.² The combination of an ordinary phone in conjunction with a pair of biconvex lenses allows users to slide their phone into the cardboard apparatus and create a three-dimensional interface.³

Cardboard is made of a sheet of cardboard, two biconvex lenses with a 45mm focal distance, one neodymium ring magnet, one ceramic disk magnet, two strips of regular adhesive-

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backed Velcro, and one rubber band to hold the phone in place (Figure 1). Design plans are available online for do-it-yourself production from cardboard or 3D printing, and pre-made kits can be purchased for several dollars from various websites.

Here, we describe the use of a modified Cardboard for smartphone-based indirect ophthalmoscopy. Its advantages lie in its head-mounted positioning, allowing intuitive use and lens position, and its cost at orders of magnitude less than traditional recording indirect ophthalmoscopes.

Most significantly, if the acrylic lens included in the package is used, then indirect ophthalmoscopy can be conducted at minimal cost and without dedicated ophthalmic equipment.

METHODS

Monocular view

To utilize the Cardboard without dedicated ophthalmic equipment, the smartphone should be moved laterally so that the screen is centered on one eye of the Cardboard device. The phone should be turned such that the camera and flash light source of the camera should face the patient. Relative to the examiner, the camera of the phone should be positioned temporally and the base of the phone positioned nasally. The second acrylic lens is then removed from the Cardboard.

Given the 45mm focal distance of the acrylic lens, the strength (22D) of the lens allows it to be used as an indirect lens for fundoscopy. It can be used either with or without dilation, although the view to the retina is clearer with dilation. It is held with one hand, between the positions where 20D or 28D lenses would be held, in front of the face of the patient.

If the Cardboard comes with straps for the head, it does not require manual support. If packaged without such a strap, it can be held with the second hand, up to the face of the examiner.

We found one modification to the Google Cardboard to be helpful, fixation of an LED as an external light source. Such LED's are available from many online retailers (e.g., amazon.com) for less than USD 0.10 per diode. This may be affixed to the front opening of the Cardboard apparatus with a watch or "coin cell" battery as in figure 1 (less than USD 0.50 at amazon.com), reducing dependence on the smartphone light source, which may vary in position between models and affect battery life. Moreover, it allows the light to be utilized independent of the program run on the phone. However, the smartphone light can be utilized for video recording, which allows both continuous documentation and consistent light.

Binocular view

To utilize Cardboard with a binocular view, both lenses are to be kept within the device, and the smartphone should be placed into the standard position. An opening should be available in the Cardboard facing the patient for the camera to have a view looking outward; however,

in the absence of such an opening, it can be produced with minimal difficulty, creating an opening in the cardboard carefully with a utility or craft knife.

Split-screen applications are available in both Apple and Android app stores, allowing the view through the camera to be seen simultaneously by both eyes. Fixation of an independent LED provides for flexibility in the choice of applications, as not all of them utilize the continuous light source of the smartphone.

Results

With these minimal modifications, we found use of the device to model the natural use of an indirect ophthalmoscope in the direction of hand movement and positioning. Sample photographs, through both dilated and undilated pupils, are evidenced in Figure 2. We utilized two commercially available acrylic lenses, 25mm and 34mm lenses in diameter (both with 45mm focal point), and found both capable.

Although no direct optical axis exists between the eyes of the examiner and patient, the real-time updating of information on the screen and rapid refresh rate can provide for adequate adjustment. For phones that support a 120Hz refresh rate, often associated with Slow Motion settings, optimal real-time visualization can be achieved. For the Android, we found that the standard video and photography application is helpful for its voice activation ability.

Discussion

In this study, we demonstrate the use of Google Cardboard to perform indirect ophthalmoscopy, independent of the need for dedicated ophthalmic equipment. The use of either mydriatic drops or an indirect lens facilitate examination and from our experience, appear decrease the learning curve, but are not necessary. As demonstrated, eye screening may be performed with materials ubiquitously available worldwide.

The use of smart-phone technology to facilitate medical practice in low-resource clinical settings has been consistently demonstrated. In a study of sixteen developing countries by the World Health Organization, 94% of healthcare programs surveyed reported using phone technology during the course of treating patients, while only 28% reported using computers.⁴ Imaging-oriented specialties such as ophthalmology would obtain particularly significant benefits from this inexpensive technology.

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References

1. Wang A, Christoff A, Guyton DL, Repka MX, Rezaei M, Eghrari AO. Google Glass Indirect Ophthalmoscopy. *Journal MTM*. 2015; 4(1):15–19.
2. Google Cardboard. [Accessed on Oct 26, 2014] Virtual reality on your smartphone. <https://cardboard.withgoogle.com>
3. Oremus, W. [Accessed on Oct. 26, 2014] Forget Oculus Rift. *Slate*. Oct 20. 2014 http://www.slate.com/articles/technology/technocracy/2014/10/dodocase_vr_google_cardboard_is_virtual_reality_in_a_25_cardboard_box.html
4. Lewis, T., Synowiec, C., Lagomarsino, G., Schweitzer, J. E-health in low- and middle-income countries: Findings from the Center for Health Market Innovations. World Health Organization; Feb 21. 2012 <http://www.who.int/bulletin/volumes/90/5/11-099820/en> [Accessed on Oct. 26, 2014]

Figure 1.

Google Cardboard. This affordable device is widely available for production using cardboard, acrylic lenses, and ubiquitous materials. Two lenses provide the examiner with a binocular, magnified view of the smartphone, placed within the device. One lens may be held in front of the device for use as an indirect lens, removing the need for dedicated ophthalmic diagnostic equipment. **Top:** Patient view of device with external LED affixed. **Middle:** Examiner view of the device. **Bottom:** Close up of “coin cell” battery and white LED that is affixed to the smartphone with electrical tape in the top panel.

Figure 2.

Sample images of Google Cardboard Indirect Ophthalmoscopy, using packaged acrylic lenses. **Left:** Through a dilated pupil and standard 25mm diameter acrylic lens included in the device, the smartphone captures features of the optic disc, vessels, and peripapillary retina. **Right, top:** Through an undilated pupil and standard 25mm diameter acrylic lens, the smartphone captures features of the optic disc and vessels, a view through which papilledema or glaucoma may be evident. **Right, bottom:** Through a dilated pupil and 34mm diameter acrylic lens, features of the retinal periphery, including vasculature, are visible.