Smartphone Indirect Ophthalmoscopy: For Screening, and Documentation of the Ocular Fundus

Rajshekhar Dyaberi, Y B Bajantri, Zain Irfan Khatib, Sneha Hedge, Vaibhav Khanna

ABSTRACT

Purpose: The purpose of this study is to describe in detail the procedure of performing indirect ophthalmoscopy using any smartphone along with instruments that are readily available in ophthalmic practice.

Materials and Methods: The procedure was performed with a smartphone and a 20D or 28D lens. Using the flashlight of the phone as a coaxial light source, the system works as an indirect ophthalmoscope where the camera creates a digital image of the ocular fundus on the phone screen through the condensing lens. High definition videos of the fundus were recorded using the inbuilt video recorder of the phone, and subsequently good quality fundus images were extracted from the video clips.

Results: With the described technique of smartphone indirect ophthalmoscopy, we were able to carry out basic screening of the ocular fundus without using a direct ophthalmoscope, slit lamp biomicroscopy or indirect ophthalmoscope. It also proved to be an excellent tool for documentation of fundus pathologies through good quality images.

Conclusion: The described technique is an easy and inexpensive way to photograph the fundus in patients using readily available portable instruments. Commercially available fundus cameras are outside the reach of many practitioners and institutes. Hence, the method seems to be a good tool for basic screening and documentation of fundus pathologies. With a small learning curve, it is relatively simple to master and takes advantage of the expanding mobile-telephone networks for telemedicine.

KEY WORDS: Condensing lens, fundus, indirect ophthalmoscopy, Smartphone, telemedicine.

INTRODUCTION

Telemedicine provides interactive healthcare utilizing modern technology and telecommunication. Smartphones were first introduced into the Indian market in the early part of the 21st century. With the ever increasing popularity and availability of smartphones, and the rapid advances in technology, almost all smartphones today have an inbuilt LED flashlight and a camera of 5 megapixels or more. As a result, smartphones have also made their way into ophthalmology as an imaging device.[1]

Ophthalmoscopy and fundus photography are an essential part of ophthalmic practice. The use of a smartphone and a condensing lens for fundus photography has been a well-established technique in ophthalmic practice over the last few years. In this study, we describe the technique of smartphone indirect ophthalmoscopy:

1. As a simple, cost-effective, portable method for screening of the retina used as an alternative to routinely used instruments (Direct ophthalmoscope, indirect ophthalmoscope, slit lamp biomicroscopy).

2. For documentation purpose, by obtaining good quality fundus photographs as an alternative to the fundus camera.

The aim of this study is to describe in detail the technique of smartphone indirect ophthalmoscopy along with the different phone settings to be used (camera, flashlight, magnification) and choice of condensing lens (20D, 28D).
MATERIALS AND METHODS

The smartphones used in the study included the Samsung Galaxy Note 3, iPhone 6, and LG I90. The condensing lenses used were the Volk 20 dioptre(D) lens and Volk 28 dioptre lens. The procedure was performed on patients in the outpatient department, retina clinic.

Principle

The phone is held in one hand while the condensing lens is held in the other hand. The LED light (present very close to the camera lens) acts as a coaxial light source to illuminate the retina. This system works as an indirect ophthalmoscope wherein the camera creates a digital image of the fundus on the phone screen through the condensing lens (Figure 1).

Technique and parameters

The technique is simple, yet may take some time to learn, because, like indirect ophthalmoscopy, the fundus image on the phone screen is inverted. Good pupillary dilatation prior to the procedure is ideal to allow for easy viewing of the fundus.

LED flashlight

It should be turned on throughout the procedure. Ideally, for the best quality of images, the least intensity of light source should be used for the procedure. The iPhone 6 and some of the android phones allow for independent control of light intensity (using applications like “Adjustable Torch” for android, and “FilmicPro” for iOS), wherein it can be set to a minimum. For the older phones which do not allow this option, a strip of micropore paper tape can be stuck over the LED light to reduce the intensity.

Camera

Phone cameras with 5 megapixels or more and those with high definition video recording are ideal. Video recording should be turned on throughout the procedure. Focus option should be set to manual so that the areas of interest can be focused better.

Magnification

Most phone cameras have ×1 to ×4 of optical zoom, which can be manually adjusted during the procedure as per requirement.

Condensing lens

Similar to standard indirect ophthalmoscopy, 28D lens gives a wider field of view with lesser magnification as compared to the 20D lens which provides a smaller field of view with higher magnification. Furthermore, the 28D lens is held at about 3-5 cm from the patient’s eye in contrast to the 20D lens which is held farther at about 7-10 cm from the patient’s eye for obtaining a clear fundus image.

The phone is held with the other hand at a distance of about 20-25 cm from the patient, being lesser when compared with standard indirect ophthalmoscopy (where the overhead light source is about 30-40 cm or one arm distance from the patient).

Once the above requirements were fulfilled, the video recording of the fundus was completed and saved to the gallery. The method of still image extraction involved replaying the video and pausing it at the desired frame in order to take a screenshot of the desired image. The images once saved, could be edited with any simple software in order to rotate, enhance or crop the fundus photos. Finally, these fundus photos were ready to be archived in the medical record or used for telemedicine.

RESULTS

With the described technique of smartphone indirect ophthalmoscopy, we were able to carry out basic screening of the ocular fundus without using a direct ophthalmoscope, slit lamp biomicroscopy or indirect ophthalmoscope. It also proved to be an excellent tool for documentation of fundus pathologies through good quality images. Figures 6-8 show some other
fundus pathologies that have been recorded by this technique.

**Phone**

While comparing the images taken from different phones, we found that the images obtained from the Samsung Note 3 and iPhone 6 were comparable with subtle differences in color contrast and saturation (Figure 2). As compared to the Samsung and LG phones which have their camera lens in the center of the phone, the iPhone has its camera lens located in the corner of the phone while the digital display is in the center of the screen. This skewed alignment of the iPhone required some practice to get the fundus imaged in the center of the screen compared to the other phones.

**Light intensity**

With manual light intensity control, we set the light intensity level to a minimum to obtain the best quality photographs. Only in older patients with cataractous changes and in patients with hazy media, we increased the light intensity slightly for better illumination of the fundus.

**Condensing lens**

We found that it was more convenient to use the 28D lens compared to the 20D lens, as the former can be held at a closer distance to the patient’s eye as described previously, thus providing better stabilization. Also, 28D lens gives a wider field of view with lesser magnification as compared to the 20D lens which gives a smaller field of view and higher magnification.

**Magnification**

From a range of 1X to 4X zoom, we found that a magnification between 2X and 3X was ideal for capturing most of the fundus details and also providing the view of the entire posterior pole in one image. For evaluating and imaging of only the optic disc, or for some localized pathology (e.g. venous loops, AV nicks, etc.), a 4X full zoom was preferred (Figures 3 and 4). Conversely, for gross screening of entire fundus, minimum 1X zoom was preferred (Figure 5).

**DISCUSSION**

High-quality fundus images can be successfully captured with a smartphone using the built-in camera and light source, along with a condensing lens. In addition, with the video capture method, the best still images can be extracted subsequently.

The study conducted by Haddock et al.\(^1\) describes a similar technique using the iPhone 4 or iPhone 5,
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along an additional application called ‘Filmic Pro’, which allows for independent control of light, focus and exposure. However, we have found that high-quality images of the fundus can be obtained with any smartphone having a camera more than 5 megapixels and a LED light, with or without the use of an additional application.

The use of a smartphone as an easy, portable method of fundus photography has been well-established in ophthalmology in the last few years.[3-5] With our experience, with vitreoretinal diseases, we have found that its use can be extended for basic screening of patients. Although the indirect ophthalmoscope and slit lamp biomicroscopy are best suited for fundus evaluation due to binocularity and stereopsis, this method of smartphone ophthalmoscopy is comparable to direct ophthalmoscopy. As compared to the direct ophthalmoscope, it provides a wider field of view. With a short learning curve, the technique can be easily mastered and can be routinely performed, even by postgraduates. It serves as an effective tool for teaching junior residents in ophthalmology. It is well tolerated in awake patients since the light intensity used is well below the light intensity used in standard indirect ophthalmoscopy.

CONCLUSION

The described technique is an easy and inexpensive way to photograph the fundus in patients with readily available portable instruments. Commercially available fundus cameras are outside the reach of many practitioners and institutes. Hence, the above method seems to be a good tool for basic screening and documentation of fundus pathologies. With a small learning curve, it is relatively simple to master and can take advantage of the expanding mobile telephone networks for telemedicine.

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