Comparison of Smartphone-based Ophthalmoscopy versus Dilated Ophthalmic Examination to Detect Ocular Pathologic Features

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BACKGROUND: Retinal imaging has improved considerably since the first photographic images of the ocular fundus were taken near the end of the 19th century. Traditionally, this approach has relied upon expensive and bulky tabletop units, operated by a trained technician in a hospital/clinic setting. These units are complex optical assemblies that require patients to be seated upright, which is often difficult for hospitalized or bedridden patients. Portable fundus cameras have recently become commercially widespread, but these are often costly or remain difficult to use in an ergonomic, hand-held manner.
To overcome these limitations, we took advantage of physicians' pervasive adoption of smartphones, which are equipped nowadays with state-of-the-art cameras. We developed a small optical device, which attaches magnetically to a smartphone, to conveniently examine and record videos or photographs of the retina. This attachment, which we call D-Eye, leverages the portability and wireless connectivity of current smartphones, making it possible to acquire retinal pictures even in remote areas, for viewing and evaluation in a clinical setting. In this article, we evaluate the ability of smartphone-based imaging to detect ocular pathologic features compared to dilated ophthalmic examination by retinal specialist ophthalmologists.

MATERIALS AND METHODS: Overall, 160 outpatients underwent dilated examination and smartphone ophthalmoscopy. Dilating eyedrops (0.5% tropicamide and 10% phenylephrine) were administered to outpatients attending the outpatient service at Spedali Civili di Brecia, Italy. After 20 minutes smartphone ophthalmoscopy was performed in these patients by a retinal specialist (AR). Subsequently another retinal specialist, masked to the findings of the smartphone ophthalmoscopy, performed a retinal slit-lamp examination according to normal clinical practice.
Smartphone Ophthalmoscopy: after pharmacological dilation, a retinal specialist (AR) performed a comprehensive dilated fundus examination with a final prototype (Figure 1) of the D-Eye adapter attached to an iPhone 5 (Apple Inc., Cupertino, CA). The images were captured on 3264 × 2448 pixels of the camera's sensor. Thus, direct fundus ophthalmoscopy was performed using live images displayed on the smartphone's screen. When the pupil is dilated, the device captures a field of view of approximately 20° in a single fundus image at a distance of 1 cm from the patient's eye. Color digital images and videos of the retina were obtained, encompassing the posterior pole, including the macula, optic disc, and peripheral retina.

Figure 1 - Picture of the prototype magnetically attached to an iPhone 5 (Apple, Cupertino, CA).

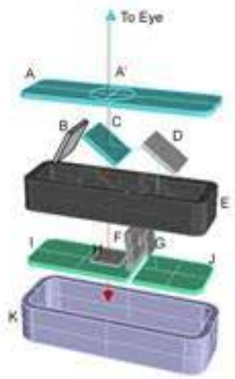
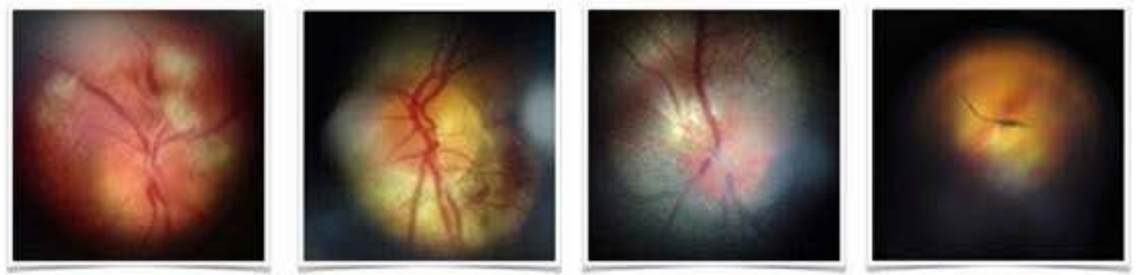


Figure 2 - Exploded view of the D-Eye module (angles and distances between components are approximated). Retinal images are acquired using co-axial illumination and imaging paths thanks to a beam splitter (C). The blue arrow depicts the path of the light; red arrow depicts the path of fundus imaging. Device components are: glass platelet (A) with imprinted negative lens (A'); photo-absorbing wall (B); beam splitter (C); mirror (D); plastic case (E); diaphragm (F); polarized filters (G, H); flash and camera glass (J, I); magnetic external ring (K).

RESULTS: Ocular pathologic features identified by digital smartphone imaging, standard clinical examination, or both included cataract; glaucoma suspicion; age-related maculopathy; chorioretinal atrophy, scar, or both; evidence of systemic disorder (hypertensive or diabetic retinopathy); retinitis pigmentosa; posterior vitreous detachment; retinal detachment.
K values for all lesions (k ≥ 0.66) demonstrated substantial agreement between smartphone-based imaging and clinical examination.

Macular Hole | Posterior Vitreous Detachment | Retinal Detachment | Retinitis Pigmentosa



Grade IV Hypertensive Retinopathy | Choroidal Neovascularization in Choroidal Osteoma | Optic Disc Glioma | Vitreous Floater

DISCUSSION: Recent literature emphasizes smartphones as valuable tools in the field of ophthalmology, while they are also beginning to play a central role as medical diagnostic tools in general. In fact, owing to the portability, data storage capability, and wireless connectivity of smartphones, it is plausible that a smartphone's fundus camera could soon play a significant role in clinical settings. Furthermore, it is estimated that more than one out of every two physicians already uses a smartphone.
In conclusion, this study demonstrates that smartphone ophthalmoscopy with the D-Eye system can be a front line tool to screen patients for ocular pathologic features.
Particularly, smartphone-based ophthalmoscopy shows promise as an alternative to the direct ophthalmoscope for improving access to eye screenings and examinations, as its portability and wireless connectivity enable potential applications such as telemedicine, even in non-hospital or rural settings.

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