How effective is smartphone-based fundoscopy in identifying diabetic retinopathy?

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Background: Over 400 million people worldwide are estimated to be affected by diabetes mellitus (DM), and of these 80% live in low or lower-middle income countries.[1] The prevalence of diabetic retinopathy (DR) is ~35%, much of which is sight threatening.[1] In the UK patients with DM undergo annual diabetic eye screening to pick up DR at it's earliest stages when it can be treated effectively by better management of DM. In later stages management of DR can include laser treatment, anti-VEGF eye injections, or surgery to remove some of the vitreous humour from the eye.[2] There are several barriers to screening on an annual bases in low and lower-middle income countries. There are a limited number of ophthalmologists in many regions and costs (including indirect costs like transport to a clinic) act as additional barriers to many. As a solution, several groups have developed attachments for smartphones which allow them to function as retinal cameras. These have the potential to provide low cost screening, including in remote areas and resource poor settings. I reviewed several studies to assess the specificity and sensitivity of these smartphone-based retinal imaging systems in detecting DR, as compared to either a normal dilated fundus examination or conventional retinal imaging.

https://www.peekvision.org

Methods: Each study assessed the accuracy of smartphone based retinal imaging in producing images which could be used to diagnose DR. Four of these studies used commercially available adaptors which attach on to a smartphone to enable it to function as a retinal camera. The fifth study (Ryan et al., 2015) did not use a commercially available adaptor, but used a 20D condensing lens held in front of the smartphone to allow the images to be produced.

Study	Camera	Eyes examined	Ungradable images	Detection of DR		Standard for Comparison
				Sensitivity	Specificity	
Russo et al., 2015	D-Eye (D-Eyecare)	240	3.75%	75-89%	93-100%	Dilated fundus examination
Toy et al., 2016	Paxos Scope (Verana Health)	100	2%	91%	99%	Dilated fundus examination
Ryan et al., 2015	Unmodified Smartphone with hand-held 20D lens	600	1.8%	50%	94%	7-field ETDRS fundus photos
Rajalakshmi et al., 2015	FOP (Remidio Innovative Solutions)	602	0%	92.7%	98.4%	Zeiss FF450 Plus digital Fundus camera
Sengupta et al., 2017	FOP (Remidio Innovative Solutions)	229	1.7%	93.1-94.3%	89.1-94.5%	Dilated fundus examination

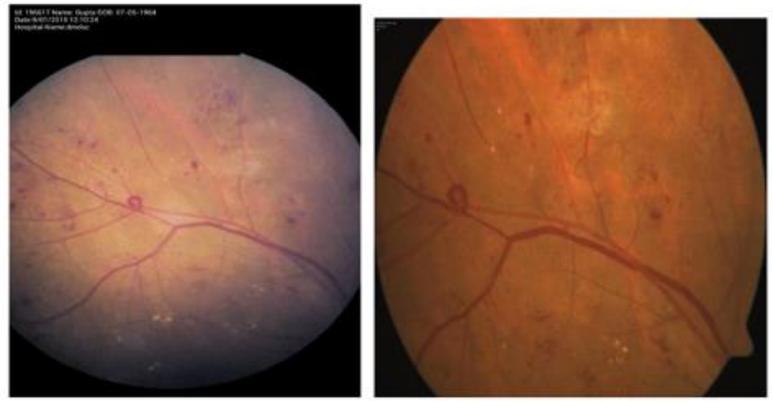
Adapted from Fenner et al., 2018[3]

Results: For the studies testing commercially available adaptors the sensitivity ranged from 75-94.3%, and the specificity ranged from 89.1-100%. These are high enough that the concept of widespread screening using smartphones should be considered. As these devices are all in the early stages of development the quality of the retinal images produced will only improve with further iterations of the adaptors and with improved cameras on smartphones.

https://www.d-eyecare.com/

Non-Proliferative Diabetic Retinopathy

Fundus on Phone | Zeiss



Rajalaksmi et al., 2015[2]

Discussion: Screening for DR in low and lower-middle income countries has the potential to overcome the challenges of screening programmes in resource poor settings and remote areas. The person taking the pictures does not need to be highly trained, in a related study assessing the use of smartphone-based fundoscopy in the diagnosis of glaucoma used a 1 hour training session for the photographers.[4] These photographs can be digitally sent to the ophthalmologist for analysis, hence increasing the possible throughput. Smartphone-based fundoscopy also overcomes issues with power, as many desk-based retinal cameras require a constant power source which may not be available in more remote settings. The systems are relatively cheap (Peek Retina can be bought for £180)[5] compared to conventional retinal cameras, which can be several thousands of pounds. A more recent study assessed the use of AI in analysing retinal images taken using smartphone-based fundoscopy to diagnose DR, finding a sensitivity and specificity of 95.8% and 80.2% respectively.[6] Thus, the burden on trained ophthalmologists may be lessened further as initial screening may be performed by AI, before analysis of difficult cases by a human. Hence access to screening could be improved significantly, reducing the burden of blindness due to DR.

1. DeBuc, D. C. The Role of Retinal Imaging and Portable Screening Devices in Tele-ophthalmology Applications for Diabetic Retinopathy Management. *Curr. Diab. Rep.* **16,** (2016).
2. https://www.nhs.uk/conditions/diabetic-retinopathy/
3. Fenner, B. J., Wong, R. L. M., Lam, W.-C., Tan, G. S. W. & Cheung, G. C. M. Advances in Retinal Imaging and Applications in Diabetic Retinopathy Screening: A Review. *Ophthalmol. Ther.* **7,** 333–346 (2018).
4. Bastawrous, A. *et al.* Clinical validation of a smartphone-based adapter for optic disc imaging in Kenya. *JAMA Ophthalmol.* **134,** 151–158 (2016).
5. https://www.peekvision.org/en_GB/peek-solutions/peek-retina/buy-peek-retina/
6. Rajalakshmi, R., Subashini, R., Anjana, R. M. & Mohan, V. Automated diabetic retinopathy detection in smartphone-based fundus photography using artificial intelligence. *Eye* **32,** 1138–1144 (2018).