WIDEFIELD FUNDUS MONTAGE IMAGES WITH SMARTPHONE: STEP BY STEP ILLUSTRATED TEACHING MANUAL

Ophthalmology

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ABSTRACT
Fundus imaging is an important investigation for Retinal patients. The imaging helps in documentation, treatment and follow up of the patients. Fundus cameras available in market are expensive and cannot be afforded by all. Moreover they are bulky and cannot be easily transported. These are not useful for immobile patients and to those who cannot be seated in front of the equipment. A much cheaper and small alternate is available. Smartphone camera can be used for fundus imaging. With little practice, reasonably good images can be obtained with smartphone. Multiple such overlapping images can be stitched with a software, creating a widefield fundus images. Such wide field imaging of retina with smartphone is not described as of now. The technique of obtaining fundus images with smartphone and creating a montage is explained in this article step by step with photos.

INTRODUCTION
Fundus Imaging is an important aspect for a retina setup. Conventional fundus cameras available in market are very expensive. Widefield fundus camera is much more expensive than conventional ones. Further, the conventional fundus cameras are bulky and cannot be easily transported. Thus, they are of no use to immobile patients and to those who cannot be seated in front of the equipment. The idea of using mobile phone's camera for ophthalmic imaging is not new. Smartphone has been described for ophthalmic photography few years ago[1]. Later smartphone was described to take fundus photos [2]. Few authors have devised adapters which help in assisting smartphone fundus imaging [3].

Here we describe a technique to obtain Widefield fundus images using smart phone and a 20D lens and a software to create montage. This technique doesn't require any adapter.

The article is divided into two parts: 1. Obtaining multiple overlapping images of fundus. 2. Creating a montage with the images thus obtained.

PRINCIPLE
It works with the same principle as Indirect Ophthalmoscopy[4]. But the viewer's eye is replaced by the camera of smartphone (Fig.1)
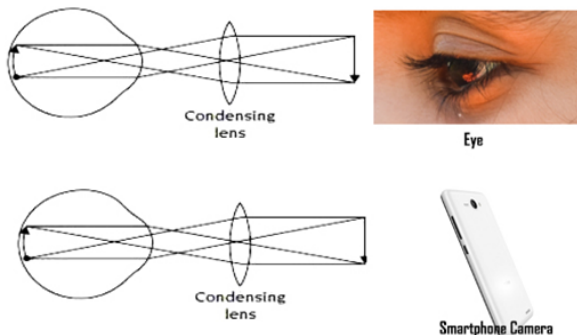

Fig. 1. Principle of Smartphone Fundus Photography.

Taking fundus pictures with smartphone needs some learning curve. I advise the beginners to follow the following steps:

PART 1: FUNDUS IMAGING WITH SMARTPHONE AND 20D LENS
STEP 1:
Take a snap of an object on your table. The object should be in the center of the photo. Keep all camera settings under "auto". Flash can be either "off" or "on".(Fig.2)

Fig. 2. *Learning Smartphone Fundus Imaging. Step 1*.

STEP 2:
Snap the same object through 20D lens. The object should be in the center of the lens. Try till you get an image with least aberrations. Note that the image will be inverted vertically and laterally. (Fig. 3)

Fig. 3. *Learning Smartphone Fundus Imaging. Step 2.*

STEP 3:
Now take a snap similar to step 2 but with flash in "Torch" mode. Try till you get an image with least reflections. (Fig. 4). Torch mode is a flash option where in the flash light is continuously on, and not just while clicking the shutter button. The flash has four options, Automatic, Flash on, Flash off and "Torch" modes. We use Torch mode, so that a continuous light is available. Most of the recent smartphones come with Torch mode. For those with no inbuilt "torch" mode, an app called "Camera360" by PinGuo Inc. can be used.

Fig. 4. *Learning Smartphone Fundus Imaging. Step 3*

STEP4:
Same as step 3 but the object is External Eye. Note that the image is not upside down. (Fig. 5). This is because the lens is 5 cm away from the eye, which is the distance for fundus imaging. For an external eye image to come upside down, the lens should be quite far from the eye, which is not necessary for the fundus imaging.

Fig. 5. *Learning Smartphone Fundus Imaging. Step 4*

STEP5:
Now go for fundus photo. The wider the pupil, the better. Use your non dominant hand to hold the lens. Use two fingers to hold the lens and the other fingers to open the lids. See that the entire lens is filled with fundus image. Try tilting the lens till the whole lens is filled with image (Fig. 6).
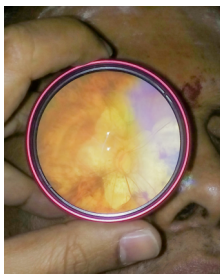
Fig 6. *Learning Smartphone Fundus Imaging. Step 5*

The whole setup us quite simple. (Fig. 7).

Fig. 7. *Distant view of whole setting. Lens is about 5cm from the eye and the phone is about one foot from the lens.*

After learning to take fundus images with least aberrations, you should be able to get photos similar or better than those shown (Fig. 8).
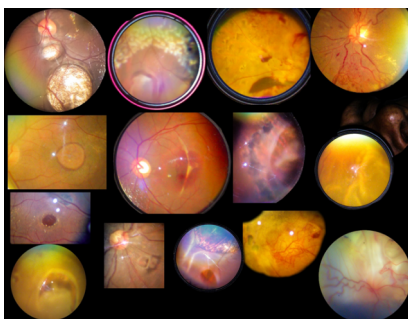
Fig. 8: *Fundus images of various lesions*

Once you have learnt to take individual photos, then go ahead with taking multiple images of a single retina in various zones. Ask the patient to move his eye in various directions and tilt your phone accordingly so as to obtain images of various zones.

Obtain multiple overlapping images of the fundus, covering all the visible retina. Ask the patient to look in various directions, just like we do for indirect ophthalmoscopy. See that the images are overlapping by atleast 40%. If the images do not overlap, creating montage would be very difficult.

Once the images are acquired, copy all of them into the computer (Laptop or Desktop). Open the images in photoshop. As a first step, remove all the areas except the fundus part, in each image (Fig. 9). In photoshop use select tool and select the fundus image. Invert the selection and delete. All the picture except the fundus image will get deleted. Make the background color black.
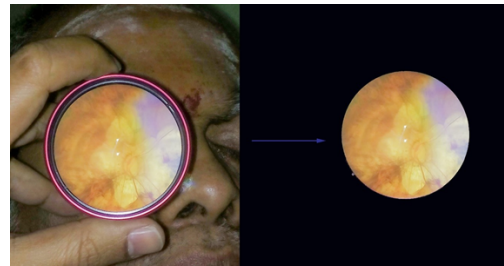

Fig. 9. *Select and keep the Fundus image and delete the excess image. Keep the background black.*

Now we have multiple photos of a single retina in a folder.

PART 2: CREATING MONTAGE
Open the Photoshop in the computer. Follow the steps as depicted in the following screenshots. (Figs. 10 to 18)
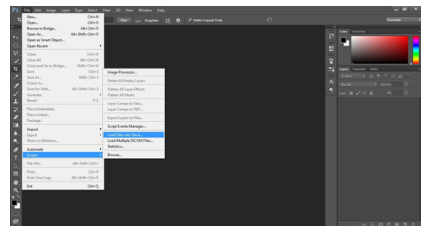

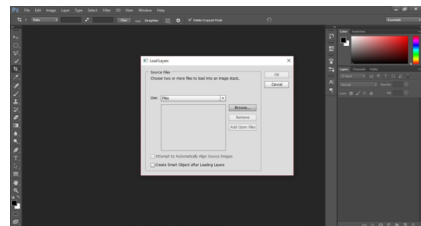**Fig. 10: File>Scripts>Load Files into Stack**
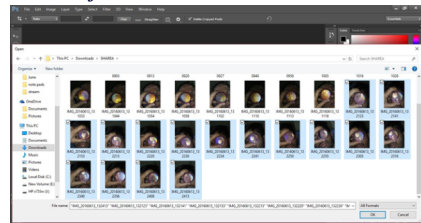

Fig. 11: Browse the folder.

Fig 12: Select all the necessary images in the folder > Ok

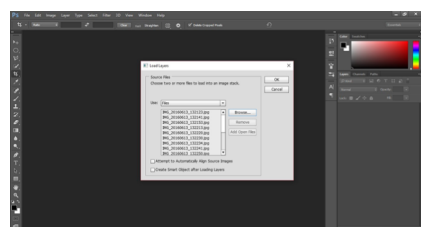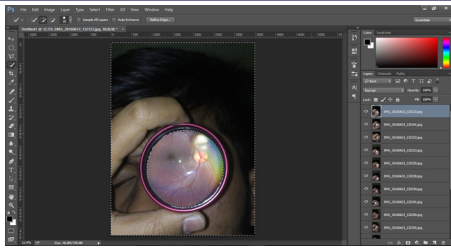**Fig. 13: Click Ok.**

Fig. 14: Select only the fundus image, and delete the rest of the image. Skip this step if it's already done.
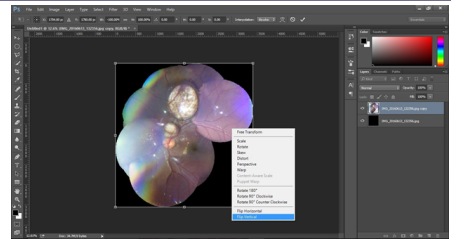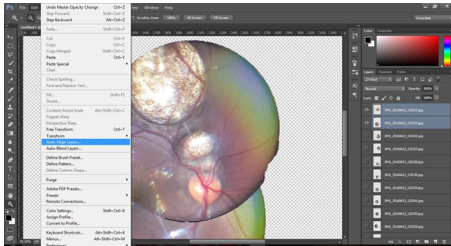

Fig 15: Select the layers needed. Select all layers if they are properly overlapping. Then Edit > Auto Align Layers.

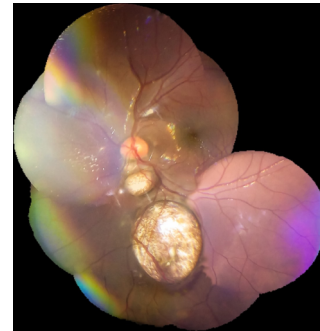*Fig 16: Once the layers are aligned. Go to Edit > Auto Blend Layers.*

Fig. 17: In the blend method, select Panorama and click OK.
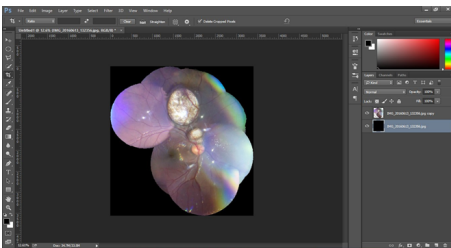

Fig. 18: Now the montage is created.

This image is inverted vertically and laterally, as it's based on Indirect Ophthalmoscopy principle. That needs to be corrected by the following steps (Figs 19 to 20).
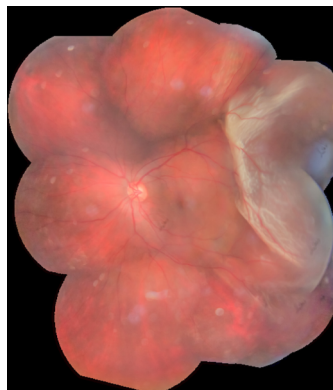

Fig 19: Go to Edit > Transform > Flip Horizontal

Fig. 20: Edit > Transform > Flip Vertical.

Save the image as JPEG (Fig. 21).

Fig. 21: The Final Image

Examples for Smartphone widefield Fundus Images (Figs. 22 to 28).

Fig. 22. Wide field Fundus photo 1. Post RD surgery with Silicone Oil

Fig. 23. Wide field Fundus photo 2. PDR TRD

Fig. 24. Wide field Fundus photo 3. Peripheral Rhegmatogenous Retinal Detachment
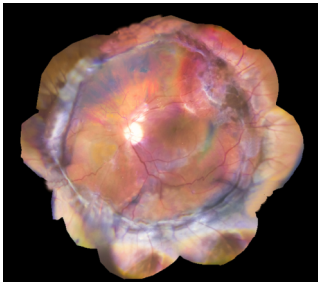
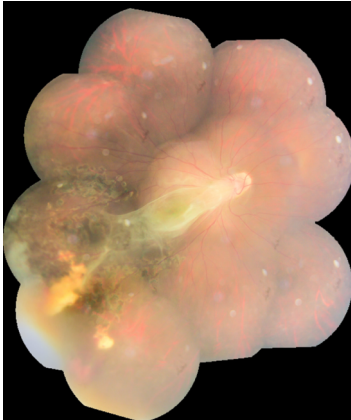*Fig. 25. Wide field Fundus photo 4. Post Buckling*

Fig. 26. Wide field Fundus photo 5. Toxocariasis.
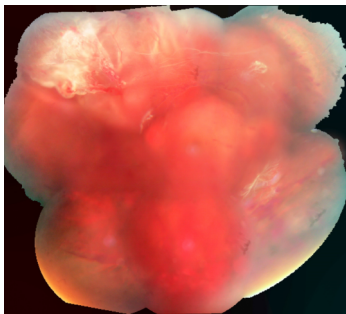

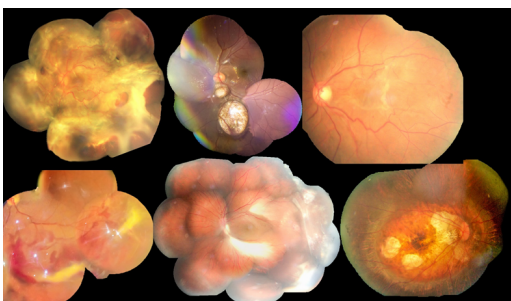*Fig. 27. Wide field Fundus Photo 6. Vitreous Hemorrhage with larger Tear with RD.*

Fig. 28. Wide field Fundus Photos. Further examples.

CONCLUSION

Smartphone can be efficiently used to create full field fundus photos.

REFERENCES

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