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Smart phone fundus camera. Make it yourself (MIY).

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ABSTRACT:
Background: How to make your own smart phone fundus camera.
Material and Methods: Materials used are cardboard role of toilet paper, cello tape, foam tape, PVC reducer (6cm,5cm ,4 cm), stapler and 20D lens .A fundus camera was created as an apparatus with slots for a 20D lens. High-quality fundus videos were captured with the device's assistance, and image extraction was simple.
Results: Easy fundus photography in two minutes.
Conclusion: Easy to make, less cost and quick photography of posterior segment.
Key words: Fundus camera, fundus photography, mobile phone fundus camera, retinal imaging, smartphone

I. INTRODUCTION

The most common technique for recording ocular fundus findings is fundus photography.[1] Traditionally, fundus photography has been carried out with a fundus camera in a clinical environment. Nevertheless, there are many settings without fundus cameras, such as hospital floors or emergency rooms, where it might be required to record any changes to the retina. Although fundus cameras are an alternative method of documenting retinal images, most ophthalmology practices do not regularly use them due to their high cost and limited availability. In ophthalmology, the use of smartphones with high-resolution cameras for anterior segment and retinal imaging is growing.[2,3]In smartphone retinal imaging, a handheld high plus power lens and the coaxial flashlight on the smartphone camera combine to form an optical system that resembles an indirect ophthalmoscopy and can capture high resolution digital retinal images.[4,5,6]Several companies sell smartphone adapters for this kind of retinal photography, and instructional videos explaining how to use smartphones and these products to capture retinal images.[7]Fundus photography using a smartphone is a practical approach due to its affordability and portability. It can be used for early detection, screening, and tracking the development of various retinal pathologies.[8].Here, we outline an inexpensive technique for creating a Make-it-yourself (MIY) smartphone fundus camera out of materials that are readily available.

II. MATERIAL AND METHODS

Materials required to Make-it-yourself (MIY) smartphone fundus camera are (Figure 1)

1. Card board role of toilet paper (10 cm length, 4 cm diameter)
2. PVC reducer (6 cm,5 cm,4 cm)
3. Foam tape (4 cm wide)
4. Stapler
5. Marker pen
6. Micropore tape/cellotape
7. Scale
8. 20 D lens

Figure 1

Method to make it:
Step 1- Join the 10 cm toilet paper cardboard role to the PVC reducer with the help of cello-tape or micropore tape. (Figure 2)

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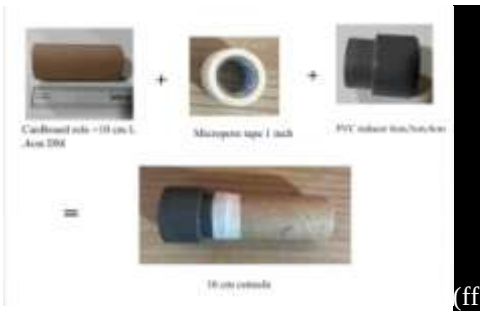

Figure 2

Step 2 – Mark 2cm from the edge of the PVC reducer and circulate two rounds of foam tape around the PVC reducer where marked. The sticky side of the foam tape is nicely adhered to the PVC reducer.(Figure 3)

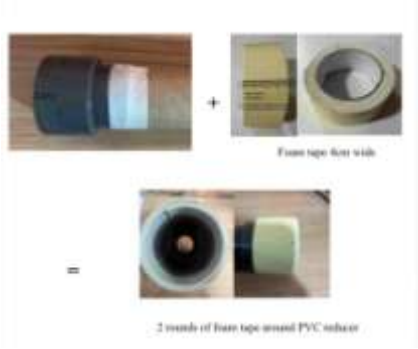

Figure 3

Step 3-The foam tape is marked from the edge circumferentially 0.75 cm from the edge and stapled around so that the foam tape does not snap out.(Figure 4)

Figure 4

Step 4 – The Volks 20 D lens which has a diameter of 5.5cm snuggly fits into the foam tape console.(Figure 5).This is how a simple smart phone fundus camera –MIY is made.

Figure 5

Method to use it:

1. Explain the procedure to the patient and obtain permission and verbal consent. Explain that the process may take 1 - 2 min and involves shining a bright light into the eye.
2.Make the patient sit comfortably in the dim light with dilated fundus. The pupil is dialted with the help of mydriatic drops such as 2.5% Phenylephrine and 1% Tropicamide ophthalmic drops prior.(Figure-6)
3. Ask the patient to look at centre of the 20D Lens
4. Enable the smart phone in video mode.
5. Set the flash to 'ON' for uninterrupted illumination.
6. MIY-smart phone fundus camera is held with the other hand close to eye approximately 3 to 5 cm.
7. Try to centrate the camera lens,20D lens and the eye in video mode to obtain images. Try to direct the camera along the patient's pupillary axis. Aim the light to the pupil and find the retina glow. Direct the light through the lens onto the retina and continue video recording.

8.While recording, move the camera and the lens to find a good focus and an image free of light reflections. Adjust the handheld MIY console to and from the patient's eye to see a clear retina image filling the entire lens area in the smart phone. It takes practice to keep the camera, handheld MIY-smart phone fundus camera, and patient pupil aligned.

9. Continue to record video until a good view of the area of interest without significant light reflections and aberrations is captured.
10. Once the examination is complete, stop the recording.
11. Re-play the recorded movie until there is a good retina view within the lens area of MIY–smart phone fundus camera is seen. Stop the movie and take a screen shot of the view.(Figure 7)

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12. Just like an indirect ophthalmoscope view, this image captured is inverted. The image is then cropped, rotated to proper orientation. This image can be stored in the gallery, shown to the patient for educational purpose, emailed or WhatsApp.(Figure 8)

Figure 6-Make the patient sit comfortably in the dim light with dilated fundus.

Figure 7-Screenshot of the fundus from video

Figure 8- Images cropped and stored in gallery or WhatsApp.

III. RESULTS

These are some of the pictures of fundus obtained by MIY-Smart phone fundus camera at GIMSR , Department of ophthalmology, Visakhapatnam with the help of I- phone 6 smart phone. Pictures were cropped and stored in the gallery.

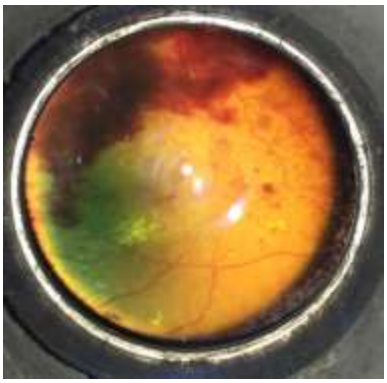

Figure 9 –Vitreous hameorrhage

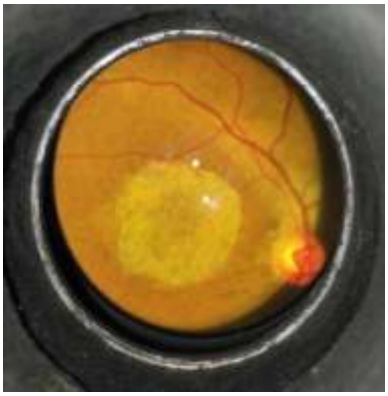

Figure 10- Retinal dystrophy

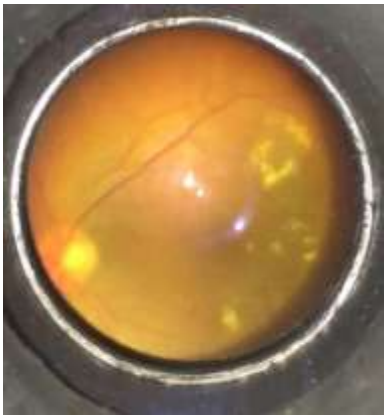

Figure 11 – Diabetic retinopathy

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Figure 12 – Central retinal venous occlusion

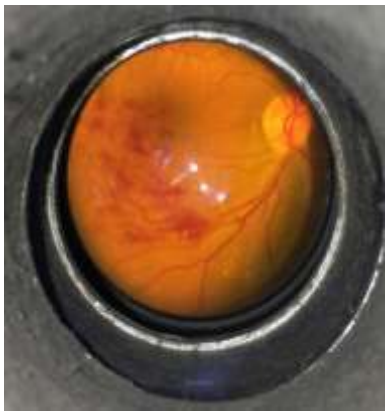
Figure 13 – Branch retinal venous occlusion

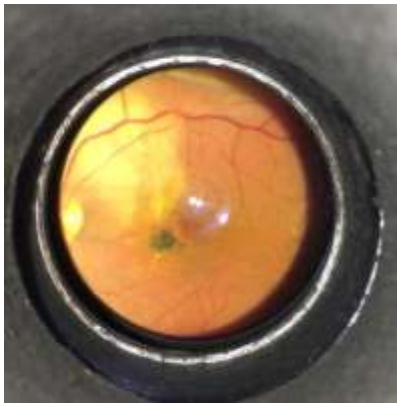
Figure 14- Choroiditis

IV. DISCUSSION

The optics of fundus imaging using a smartphone camera-MIY is similar in principle to retina examination with indirect ophthalmoscope.(Figure-15)

Similar to an indirect ophthalmoscope, a light beam is focused on the patient's retina, and a +20D lens is used to condense the rays that reflect off the retina to create an actual aerial image. The actual, inverted aerial image, which is situated 2–4 cm from the lens, is visible to the viewer. With a smart phone, the camera's flashlight replaces the indirect ophthalmoscope light source and the smart phone camera recording the aerial image replaces the observer's eye.

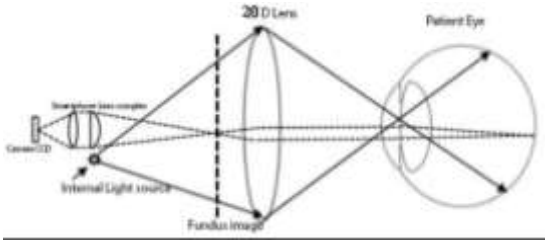

Figure-15

Advantages of MIY-smartphone fundus camera:

- **Cost effective-** Cardboard role(free)+Micropre tape-Rs40+Stapler-Rs100+Foam tape +Rs70+Scale Rs5+Marker pen-Rs25+PVC reducer Rs40 =Rs280
- **Easy Use-** It is easy to use the 20D lens by snuggly fitting and taking it out.
- **Portable-** It can be carried easily to all places.
- **Any smart phone-** It can work with any smart phone with flashlight and single camera.
- **Time-** Less time consuming (with practice, it takes 2 minutes).
- **Images-** It can be shared in WhatsApp or e-mail.
- **Screeing –** It can be used by optoms /any health workers for diabetic screening.

Disadvantages of MIY-smartphone fundus camera:

- Dilated pupil of the patient is required.
- Alignment of fundus camera and the smart phone camera required.
- Learning curve to get proper images.
- The field of view is 40° to50°
- Quality of image is nowhere near the professional desktop camera due to glare, improper exposure, screenshot of the video and chromatic aberrations.
- It is not suitable for smart phones with multiple cameras.

A patient who cooperates, a well-dilated pupil, clear ocular media, and an experienced examiner are necessary for capturing a high-resolution smartphone retinal image. The images obtained with a smartphone may be comparable to those obtained with a fundus camera.[9]Additionally, the field of view in fundus photos taken with smartphones is typically restricted, and producing widefield montage images can take some time. However, smartphone fundus photography is a novel, easy-to-use, and reasonably

priced method that makes it possible to take pictures of changes in the retina in many clinical settings where retinal imaging was previously not feasible.

V.CONCLUSION

MIY- smart phone fundus camera is simple, cheap, portable and an easy method to image retina. It can serve as an alternative to high built costly fundus cameras which may not be available in all centres. It can be easily made and used by ophthalmologist, residents, technicians and optometrist to take fundus pictures for educational, disease screening and telemedicine purpose once they master the art.

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CONFLICTS OF INTEREST
There are no conflicts of interest.

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