Technique

Smartphone Fundus Videography For Documentation Of Retinal And Optic Nerve Head Diseases

Rajesh Hans,[1] Mohmad Uzair,[2] Aditi Kaushik[1]
[1]Department of Ophthalmology, Deep Chand Bandhu hospital , kokiwala Bagh, Ashok Vihar, New Delhi, India.
[2]Department of Ophthalmology, Deen Dayal Upadhyay Hospital, Hari Nagar, New Delhi, India.

Abstract

Ophthalmological services are required everywhere throughout the country. The lack of availability of the equipment's like fundus camera at most of the smaller centers is still a discouraging factor for documentation of retinal and optic nerve head diseases. The smaller centers fulfill this need by referring the patients to tertiary or higher centers. Here, we describe a technique of Smartphone Fundus videography (SFV), which may prove useful for the necessary documentation. The generated data by this technique may be stored in any easily available electronic hardware and software. This data may also be used for temporal comparison of the diseases in the patients following up at various clinics by easily sharing the data using widely available smartphone applications.

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Keywords: *Fundus, Fundoscopy, Fundography, Fundus Camera, Smartphone Fundography, Smartphone Videography, Smartphone Fundus Videography.*

Introduction

Fundus photography is an essential technique in ophthalmology for documentation and monitoring progression of retinal and optic nerve head diseases. Conventionally, it is done by fundus camera which is many times not available in smaller setups. Smartphone photography and videography has been used with increasing frequency since 2010, as first reported by Lord and colleagues.[1] Other academia-based smartphone attachments/apparatus have been developed and tested using general principles of direct and indirect ophthalmoscopy.[2] The simplest, lowest-cost setup is using a smartphone and an indirect condenser lens in patients with dilated pupils.[3] This technique is very simple, convenient and economical for the ophthalmologists at smaller setups, to document the central retina, optic nerve head and peripheral retina even beyond 60 degrees.

Principle of Binocular Indirect Ophthalmoscope

The most useful, successful variant of the ophthalmoscope is the binocular indirect headband ophthalmoscope, first described by Charles Schepens in 1945.[4] The indirect ophthalmoscopy is done by making the eye myopic, while using a strong convex lens in front of it. This forms a real inverted image of the fundus in the air between the lens and the observer. The usual powers of condensing lenses used are +20 D and +13 D. The lens is positioned in such a way that it changes the direction of diverging rays emanating from the subjects' eye and brings them to a point focus within the pupillary plane of the observer's eye. If the patient is emmetropic, the rays of light from the subjects' eye are parallel, but this changes as these rays pass through the condensing lens. As the rays of light enter the lens with zero vergence, they are brought to focus in the focal plane of the condensing lens. The observer focuses the aerial image using accommodation. (Figure 1)

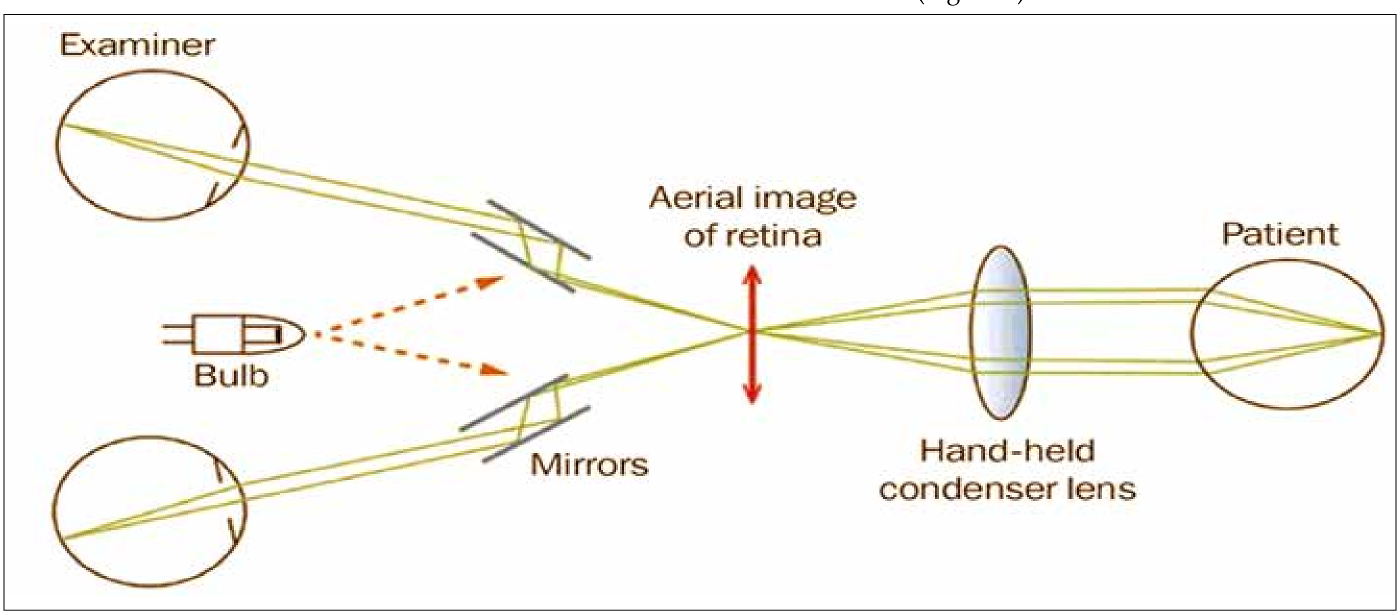

Figure 1: *Principle of Binocular Indirect Ophthalmoscope.*

Principle of smartphone fundus videography (SFV)

The optics of fundus imaging using a Smartphone camera is similar in principle to retina examination with indirect ophthalmoscope (Figure 2).[5] The real, inverted aerial image from the handheld lens is focused with a Smartphone, the camera's flashlight replaces the indirect ophthalmoscope light source and the Smartphone camera recording the aerial image replaces the observer's eye.

Various Products Available In The Market For Smartphone Fundus Photography

Currently, there are various apparatus and software packages in the market for smart phone fundus photography. DigiSight Paxos Scope (San Francisco, USA),[6] Peek Retina (London, UK),[7] D-EYE (Padova, Italy),[8] Remidio Fundus on Phone (Bangalore, India)[9] and Welch Allyn Panoptic with iExaminer (Skaneateles Falls, USA)

Materials and Methods

The patients visiting our retina services clinic and glaucoma services clinic were enrolled for the purpose of SFV. The patients having systemic hypertension, coronary artery disease, cerebrovascular accident, any corneal, conjunctival disease and significant media opacity were excluded from this study. The procedure was explained to the patient and written consent was obtained. The pupils were dilated using 2.5% Phenylephrine and 1% Tropicamide ophthalmic drops (one drop 5 minutes apart, in both the eyes for three times). The patient was made to lie down on examination table in a dark room. Proparacaine 0.5% drops were instilled in both the eyes till anaesthetic effect was confirmed by cotton wick test. The universal wire speculum was applied to the patient's eye and the cornea was coated with Hydroxypropyl methylcellulose 2% (HPMC) to prevent the drying up of the corneal surface.

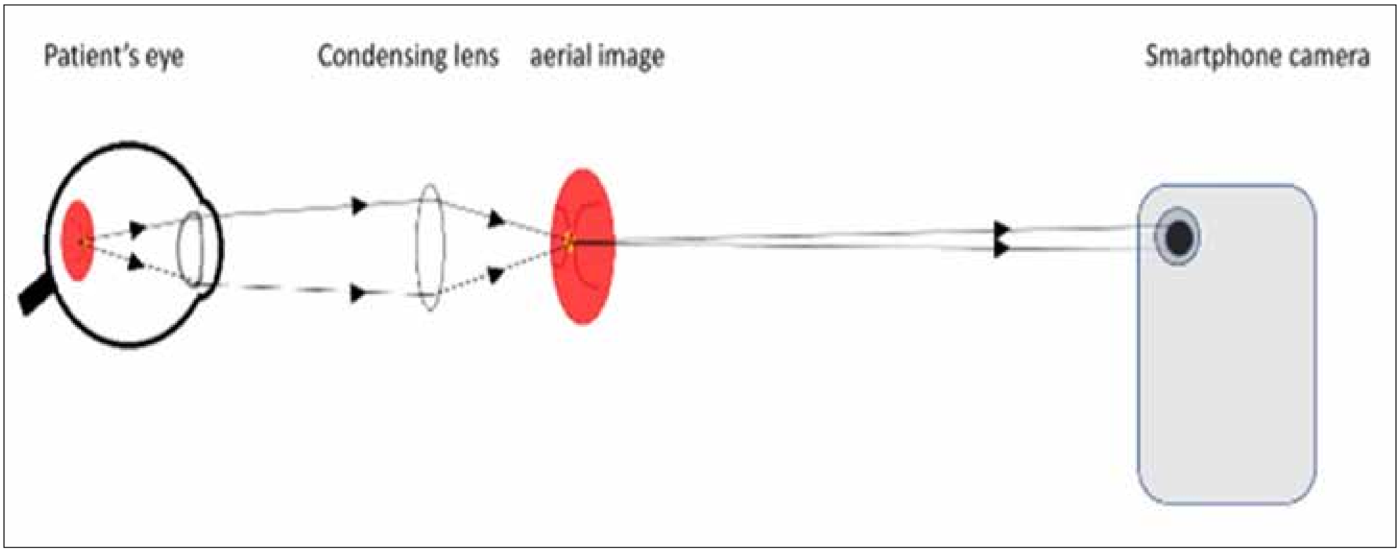

Figure 2: *Optics of Smartphone fundus videography.*

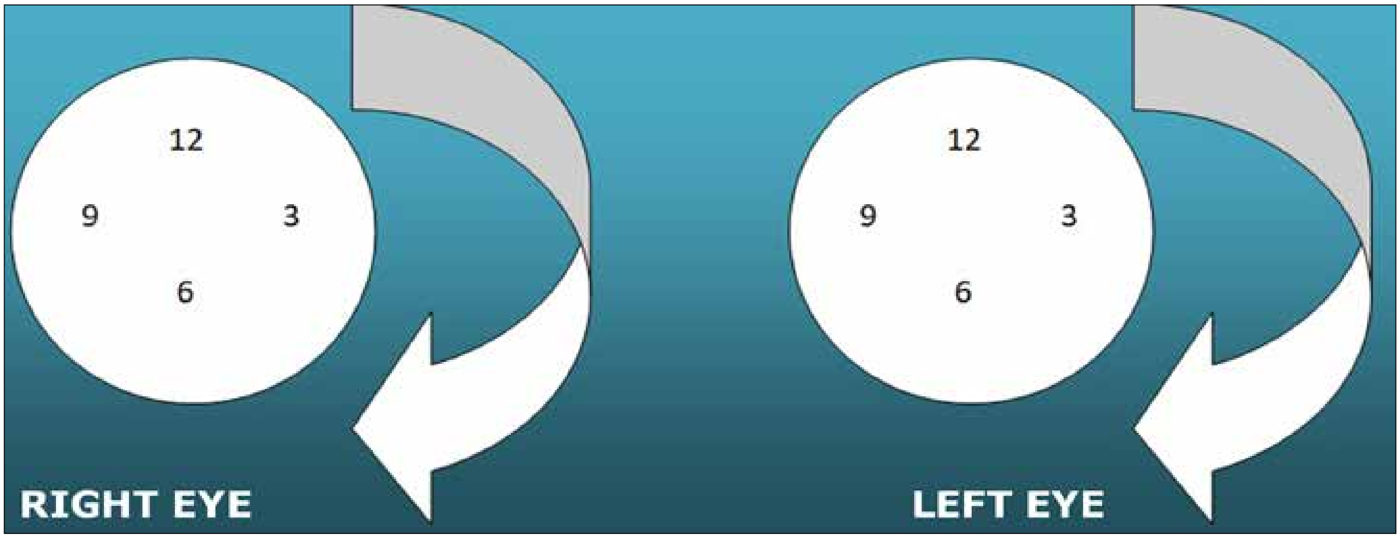

Figure 3: *Diagram depicting the clockwise rotation from 12 o' clock position for SFV documentation.*

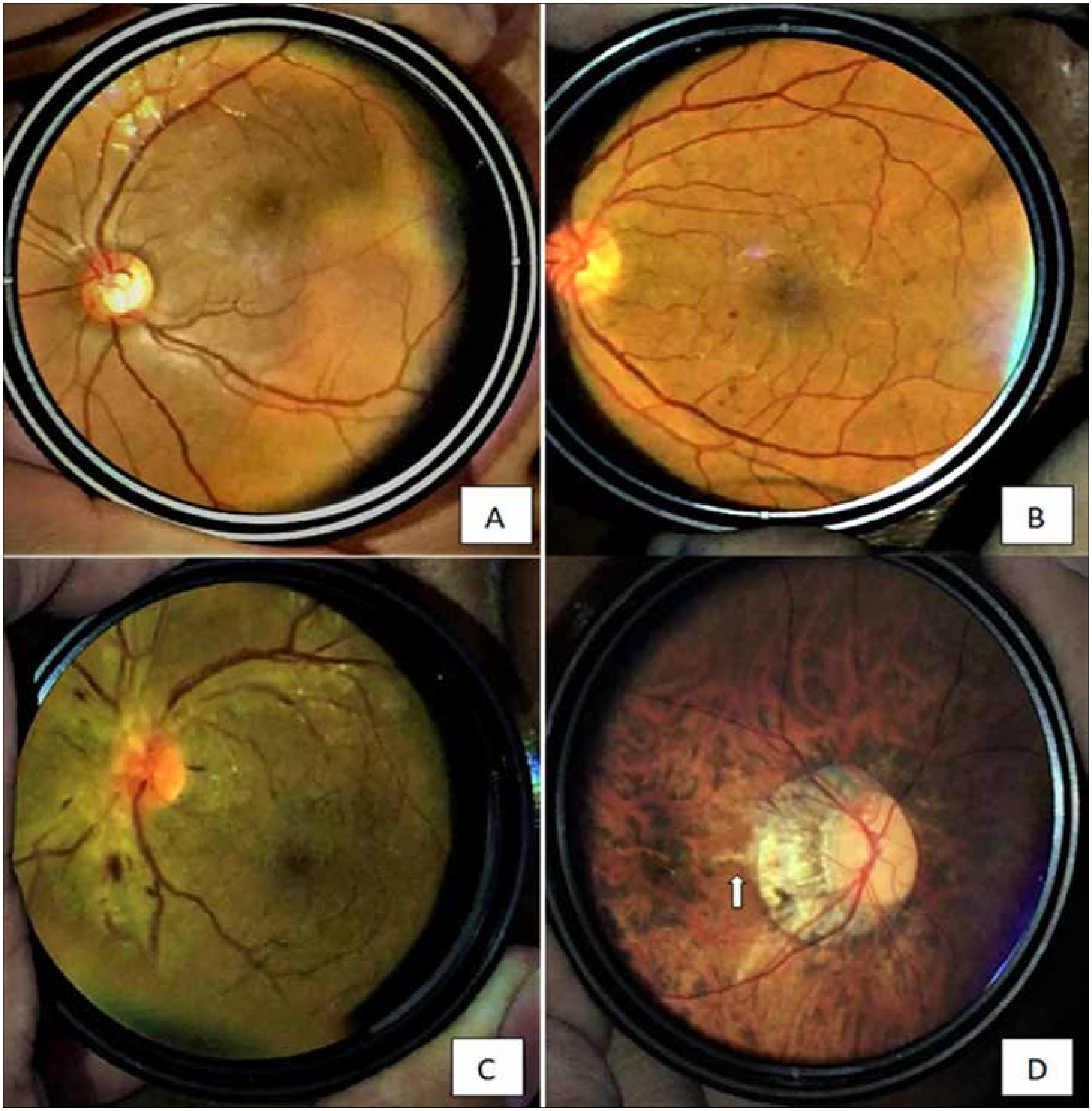

Figure 4: *(A) 0.7:1 CDR, deep cupping, inferior NRR thinning, bayonetting in a patient of POAG.*
(B) 0.3:1 CDR with Mild NPDR in a patient of diabetic retinopathy.
(C) Disc edema, peripapillary retinal edema ,flame shaped haemorrhages in a patient of raised ICT.
(D) large pale disc with temporal cresent , tessellated fundus and angiod streaks (white arrow) in a patient of high myopia.

Right eye was examined first. The fundus was videographed using Smartphone's camera (device used was iPhone 7 plus) with flashlight On. The +20 D lens was held between 4-5 cm in front of the patient's eye with thumb and index finger of non dominant hand. The smartphone was held between 15-20cm from +20 D lens in the dominant hand of examiner preferably for manipulating the smartphone controls and this distance is varied with different smartphones. Intensity of exposure can be increased or decreased by tapping on smartphone's screen while video recording according to the requirement. It is better for examiner to be ambidextrous to increase the ease of videography.

The 12 o 'clock position was video graphed first of all, then the clockwise rotation of videography was done and the central fundus was video graphed at the end of the procedure. The patient was given the thumb of the contra

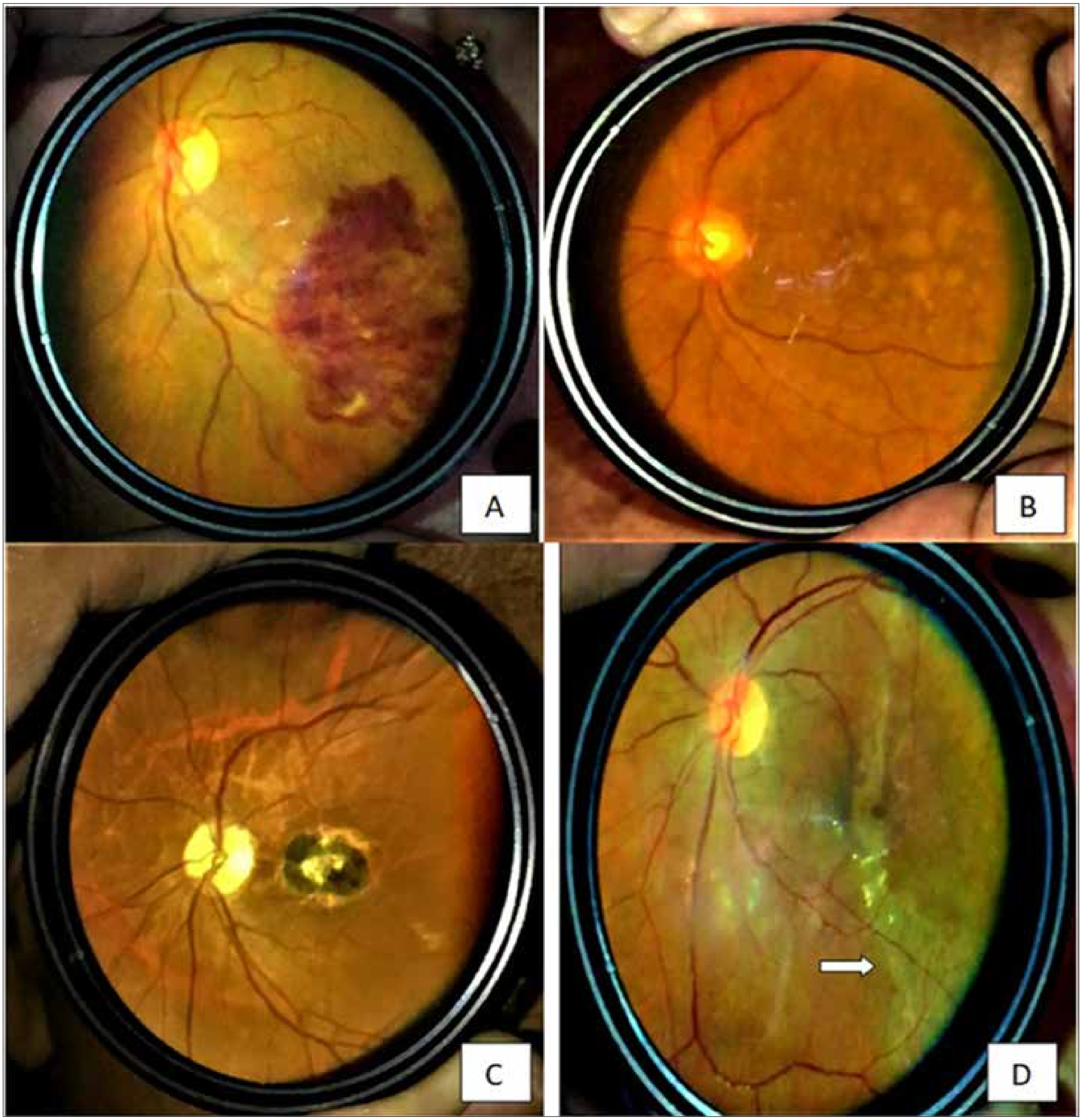

***Figure 5**: (A) Infero-temporal BRVO with haemorrhages involving macula.*
(B) Multiple soft drusens in the macula.
(C) Pale disc with macular scar in a patient of toxoplasmosis.
(D) Demarcation line (white arrow) passing through macula in a patient of infero-temporal retinal detachment

lateral hand as target (Figure. 3). The light was directed through the lens onto the retina and videography was done. The intensity of the light was varied as per the media haze and patients comfort. While doing videography, it was ensured that the full image was visible throughout the +20D lens and image was free of surface reflections. At the end of procedure the wire speculum was removed and topical antibiotic (Tobramycin 0.3% eye drop) was instilled in the examining eye. The fundus videography of left eye was also conducted by the same technique. The required photographs were extracted from the videos by taking screenshots of smartphone depending on area of interest. All the clinical photographs obtained from the videos were rotated by 180 degree for the purpose of documentation.

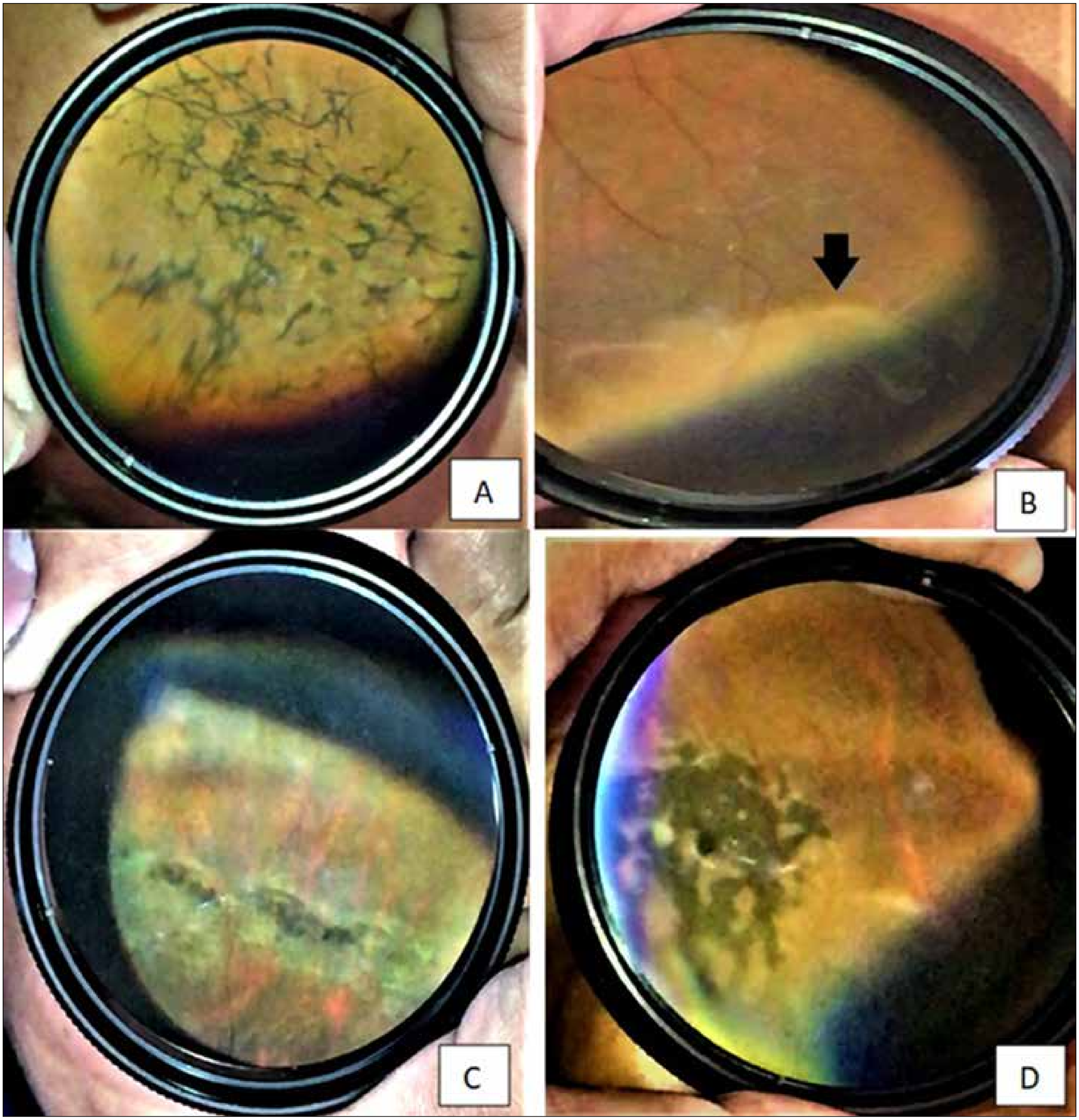

Figure 6: *(A) Multiple bony spicules in a patient of RP.*
(B) Peripheral retina showing second and third level dichotomous branches of retinal veins with peripheral WWOP area (black arrow)
(C) Pigmented lattice degeneration in patient of myopia.
(D) A typical lesion of CHRPE in the peripheral retina of a patient of Gardner's syndrome.

Results

Using the SFV technique, the obtained results are reproduced below (Figures. 4, 5 and 6). (Figure 4)shows the optic nerve head conditions. (Figure 5) shows macular conditions and (Figure 6) shows peripheral retinal conditions.

Discussion

Smartphone fundus videography (SFV) technique used by us was found to be of high quality. The photographs were extracted from the videos for the purposes of documentation, student training, monitoring the disease progression, cross consultation and patient education. The advantages of SFV technique are that the examiner can reach extreme peripheral retina (beyond 60 degree) in all the quadrants and can document it. This technique is very economical and does not need availability of fundus camera. This technique can also be used in non-ambulatory patients. The examiner can easily go to various locations and document the images. This technique is highly patient friendly and generated data can be stored in various electronic hardware and software applications easily available everywhere. It takes practice to keep the camera, handheld lens, and pupil aligned. The learning curve of this procedure is short, even eye technicians/ staff can be easily adapted. The quality of fundus videos taken by smartphone could be comparable to that of fundus cameras. In one comparison study of fundus images taken by smartphones and fundus cameras, masked reviewers did not find a significant difference.[10,11] Smartphone fundus photography is a safe technique.[12] Although light intensity and energy have not been measured for other smartphone models, it is suggested that they can be well below hazard limits.[13] Nevertheless, smartphone fundus photography is a unique simple and affordable technique that allows picture documentation of retinal changes in many clinical settings where retinal imaging was not previously possible. Smartphones are ubiquitous with high-resolution cameras being upgraded regularly. However, SFV may be difficult in non co-operative patients and children. The anesthesia support may be needed for performing SFV in such cases.

The prevalence of DR in urban areas is between 13–18% and in rural areas is 9–10%. The incidence of diabetic macular edema (DME) and sight threatening diabetic retinopathy (STDR) increased to 11.5% and 22.7% respectively.[14]

There are approximately 11.2 million persons aged 40 years and older with glaucoma in India.[15] Considering this disease burden, it is impossible for tertiary care centers to provide evidence based treatment to the widely spread population suffering from the above diseases. The smaller setups will be important in giving the required treatment at their level for a large proportion of the above population. SFV is also an enabling technique in the hand of practitioners as by using this technique they need not send the patients to higher centers even for basic documentation. They can also use still photographs generated for baseline documentation, progression of disease and sharing of photographs as per the laws of the country.

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Address for correspondence

Mohmad Uzair (M.S)
Senior Resident, Department of Ophthalmology, Deen Dayal Upadhyay Hospital, Hari Nagar, New Delhi, India
Email : Mohmad.uzair90.mu@gmail.com

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