Innovation in Ophthalmology

Smartphone-based intraocular lens microscope

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Microscopes play an important role in the diagnosis of microorganisms and pathological lesions in ophthalmology guiding us to the appropriate management. The current trend of collecting samples and examination is mostly laboratory-based which consume time, labor, and are costly. Smartphones are being used in different fields of ophthalmology with great ubiquity. The good quality photographs obtained by smartphones along with the ease of mobility has made it possible to warrant its use in the microscopic world. This article describes a simple novel technique of preparing an intraocular lens system which can be used in conjunction with a smartphone to detect microorganisms and pathological lesions.

Key words: Innovation, low-cost device, microscope, point of care diagnosis, smartphone photography

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The microscope is the visual bridge connecting the colossal macro-universe to the micro-universe of a living organism. The introduction of the microscope in the 16th century has been a boon in the field of science which has made us realize that there is a world that is too small to be seen by the naked eye.[1] It has become a ubiquitous tool for research in ophthalmology and provides a resolution of 250 nm and smaller.[2] The conventional light microscopy has been modified time and again to give finer resolution, some of them being the electron and X-ray microscope, fluorescence confocal microscope, two-photon laser scanning microscope which has allowed us to map the structures of the living cell and also microorganisms.[3-6] The use of these microscopes in ophthalmology is largely restricted to the laboratory which is costly, time-consuming, and labor-intensive.[7] There is growing interest to develop tools for health monitoring which can be used in a clinical setting and fields/camp setups.[8-10] Point-of-care (POC) diagnostics are being developed by researchers to offer advantages over the conventional laboratory-based evaluation methods, providing portability, automation, faster processing time reduced sample volume and lower cost.[11] The goal of POC is to make diagnostic testing widely accessible such as in clinics, outpatient departments, camps, ICUs, PHC's, etc., and also to make it cost-effective ultimately improving several sectors of healthcare with early detection, health maintenance, and therapeutic monitoring. POC has also been used in other fields such as identification of animal and plant pathogen, biological warfare agent detection, food quality assurance, environmental monitoring, identifying, and analyzing biological targets (nucleic acid, chemical compounds, proteins, metabolites, and biological cells) in environmental and clinical samples.[12-20]

Smartphones are being used in ophthalmology to acquire anterior and posterior segment photographs with impressive details which establish it as a good tool for documentation. Smartphones are now also been used in the detection of cellular microorganisms, parasites, subcellular proteins, and nucleic acids. It is a useful POC diagnostic tool for fungal keratitis.[21-31]

We describe in this article a technique to prepare a microscope by attaching the smartphone with an optical system made up of IOL's (expired/those which have broken haptics/unsterile/unfit for intraocular use), hence named the IOLSCOPE (Smartphone-based IOL microscope) and also how to use it as a reliable POC diagnostic tool.

Method

Preparing the IOLSCOPE [Fig. 1a]

- A single strip of 4 cm × 2 cm black hard chart paper was cut
- A circular opening of 5 mm was made using a paper punching machine at one end. [Fig. 1b]

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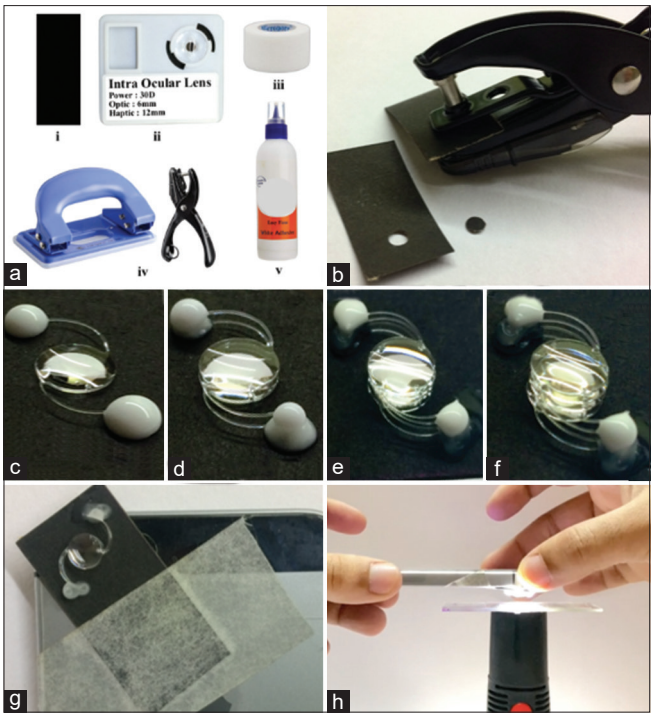

Figure 1: (a) Materials used to prepare IOLSCOPE; i. Black chart paper strip measuring 4 cm × 2 cm, ii. Intraocular Lens - 30D four in number, iii. Micropore, iv. Paper punching machine, v. Liquid adhesive, (b) Circular opening of 5 mm made on one end of the black strip using the punching machine, (c-f) Placing the first IOL on the circular hole and the subsequent IOL's one upon the other by applying liquid adhesive, (g) Placing the optical device on the camera of the smartphone using micropore, (h) Placing the slide on a light source (torch) and taking pictures by approximating the iolscope to it

- The intraocular lens taken here was all of power 30D. The intraocular lens was placed in the circular opening by applying liquid adhesive over the haptics of the IOL and is left to dry
- The second IOL was placed carefully above the previous IOL by applying liquid adhesive on the haptics and left to dry. The above steps were repeated to place two more IOL's. [Fig. 1c-f]
- This optical arrangement was then aligned on the smartphone camera with a micropore/cello tape [Fig. 1g]
- Any prepared slide was the placed-on top of a light source (top of torchlight, white screen of a smartphone, etc.)
- The smartphone attached to the optical device was then brought near the slide and focused to get the required microscopic image from the slide [Fig. 1h]
- The digital zoom of the smartphone can also be used to get even more enlarged images, although the clarity depends on the smartphone, and the camera used
- The microscopic images obtained were of good quality and can be used to identify fungal hyphae and the fungus, pathology slides, and also larvae of parasites [Fig. 2 and Videos clip 1-6].

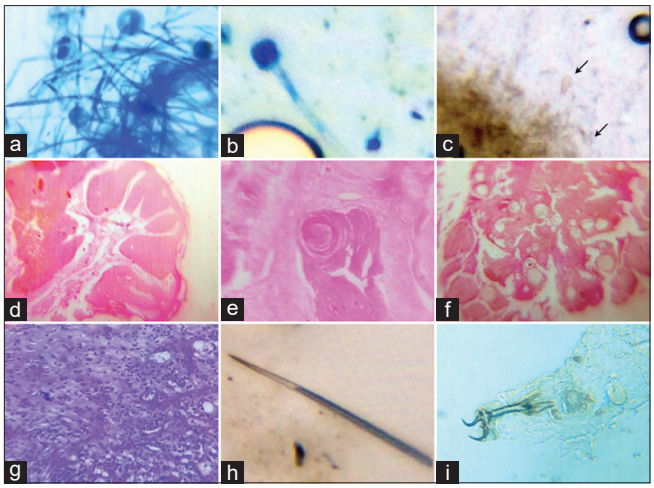

Figure 2: (a) Lactophenol cotton blue (LCB) stained mount of *Rhizopus*, (b) LCB stained mount of *Aspergillus*, (c) Fungal hyphae and spores (black arrow) in KOH mount, (d) Histopathology slide of Basal Cell Carcinoma (BCC), (e) Histopathology slide of Squamous Cell Carcinoma (SCC) with keratin pearl, (f) Histopathology slide of Rhinosporidisosis with multiple round sporangia, (g) H and E stained histopathology slide showing inflammatory cells, (h) Caterpillar hair showing spines along the shaft, (i) Anterior end of the first larval stage of Oestrus ovis equipped with cephalopharyngeal skeleton showing two dark sharply curved oral hooks

Discussion

Smartphones have revolutionized the way we see healthcare. It has proven time and again as a reliable technology for POC diagnostics. Smartphone telemedicine is being used in ophthalmology for fundus photography and also anterior segment pathologies in rural centers. Early and accurate detection of microbes helps in the diagnosis of a disease and the appropriate treatment.[32-35] It is often delayed and with the advent of smartphones, it is possible to have cost-effective and quick POC for diseases which overall helps us in providing a better quality of treatment to the patients. The IOLSCOPE can be used as a powerful tool for POC diagnosis by imaging microscopic organisms. It is useful especially for ophthalmologists in diagnosing fungal keratitis by imaging a KOH mounted slide. An added benefit of digital zoom helps in viewing the structures even better. The ability to take record images and can be relayed through the internet to microbiologists for an expert opinion. This device can be made by anyone with IOL's which are unsterile, expired, or those which are broken but with an intact optic. The scope of IOLSCOPE is such that it can be used not just in ophthalmology but other subspecialties such as pathology, microbiology, dermatology, etc., This is a preliminary step towards screening of disease but not a confirmatory test such as examination with a light microscope and culture-based diagnosis which continue to remain the gold standard confirmatory procedure for diagnosis.

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Conflicts of interest

There are no conflicts of interest.

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