

Slit-lamp based intraocular lens microscope - A novel technique of rapid office-based microscopy

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The emergence of smartphone-based imaging devices has been a boon in the field of ophthalmology, especially in obtaining high-quality ocular images. They can be specialized and utilized for imaging-specific regions of the eye. Among the multitude of applications of smartphone-based imaging, one of the upcoming major use is to image the microbiological world. Previous few reports have described attaching magnifying lenses of various types to the smartphone camera and transforming it into a microscope for imaging fungal hyphae and ocular surface parasites. We describe a novel technique of attaching the smartphone-based intraocular lens microscope (IOLSCOPE) to the slit lamp, thereby utilizing the slit lamp joystick for moving the smartphone over the concerned slide specimen to make it steady and obtain images of high resolution. This innovative do-it-yourself novel modification is especially useful in peripheral centers, vision centers, and local clinics for immediate screening and identification of microbial pathogens such as fungi and ocular surface parasites.

Key words: Innovation, IOLSCOPE, microbiology, microscope, smartphone

The microscope invention has been an important tool aiding in the understanding and diagnosis of various microbiological pathogens. It is of immense use in ophthalmology, especially in providing a spot identification of disease-causing microbes such as bacteria and fungi, which cause infective corneal ulcers as well as identifying ocular surface parasitic larvae. Microscopes have constantly been upgraded in terms of resolution providing high sensitivity for pathogen detection.^[1] Accessibility to a microscope as well as lack of technical facilities in a remote setting can be difficult, thereby causing a delay in diagnosis and treatment of disease.^[2] Recently, smartphone-based imaging devices have emerged, which utilize the imaging capability of a smartphone, thereby enabling its use in ophthalmic photography. They can be used to image the anterior segment, angles as well as posterior segment and have been an immense boon in the field of teleophthalmology.^[3] Additionally, smartphones have also been used as a microscope aiding in immediate pathogen identification as well as for describing histopathological specimens.^[4] These smartphone-based imaging devices are portable with either an add-on attachment or modification of the built-in camera for advanced and magnified imaging. A recently described smartphone-based microscope is the smartphone-based intraocular lens

microscope (IOLSCOPE), which can be used as a reliable point of care diagnostic tool providing high-resolution magnified images.^[5] Microbial or histopathological image acquisition requires the concerned slide to be mounted onto a torchlight and manually approximating the IOLSCOPE to the slide and focusing onto the image while holding the smartphone with both hands. In this article, we describe attaching the IOLSCOPE using a smartphone adapter to the mechanical arm of a slit lamp, thereby providing a hands-free platform for its mechanical movement by manipulating the slit lamp joystick. We term this assembled apparatus as a slit lamp-based intraocular lens microscope (SLIM) [Fig. 1].

Innovation

Preparing the IOLSCOPE: A chart paper of 4 × 2 cm was taken in which a hole was made at one end with a paper puncher and four IOL's of 30D were stacked one upon the other and fixed using a liquid adhesive. The arrangement was then aligned over the smartphone camera (iphone5s). The IOLSCOPE was then fixed to the smartphone holding end of the adapter as shown in Fig. 2a and b.

Assembly of SLIM: The slit lamp has a co-pivot mechanical arm to which the illumination and optical arm is attached as shown in Fig. 2c. Here, the illumination arm was carefully dismantled and the other end that is the slit lamp connecting

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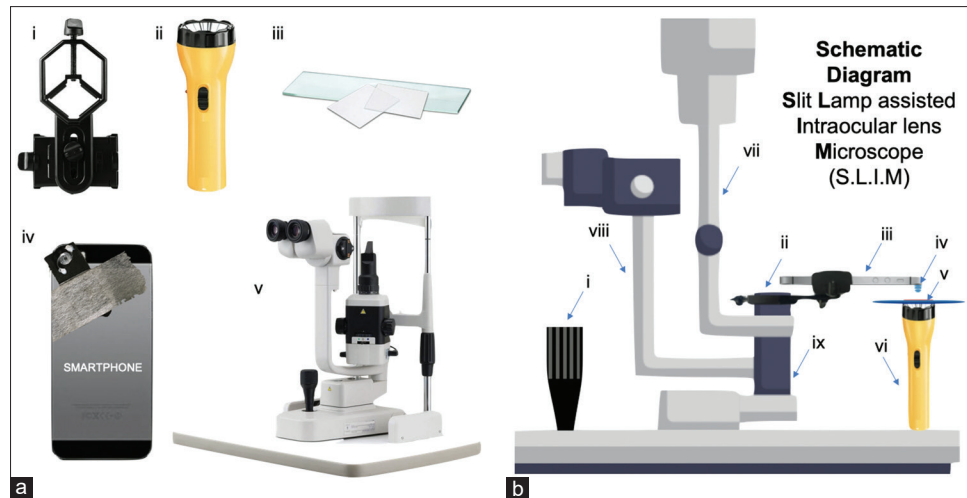


Figure 1: (a) Materials required for assembling the slit lamp based intraocular lens microscope (SLIM); i. smartphone holding adapter, ii. Torch, iii. Slides, iv. Smartphone based intraocular lens microscope (IOLSCOPE), v. Slit lamp; (b) Schematic diagram of SLIM; i. slit lamp Joystick, ii. Smartphone adapter, iii. Smartphone, iv. IOLSCOPE attached to smartphone, v. Sample slide, vi. Torch, vii. Illumination arm of slit lamp, viii. Optical arm of slit lamp, ix. Co-pivot mechanical joint of slit lamp

the end of the adapter to which the IOLSCOPE was attached is fixed. The illumination arm was then placed back onto the co-pivot mechanical arm. The screw of the mechanical arms was then tightened as shown in Fig. 2d-h. The SLLM is ready.

The slide to be examined can be placed on a torchlight, and the joystick of the slit lamp helps us move through the field of the slide and also helps in focusing the sample with great ease. A video or photograph of the specimen can be taken as and when required [Fig. 2i].

Discussion

We live in the era of technology and its advancements with new innovations in our everyday lives, leading to reduced dependency on expensive equipment and increased development of cheaper tools. Affordable equipment for the screening, diagnosis, and management of the major causes of preventable blindness can positively impact millions of Indian lives and billions worldwide.^[6] Smartphones have gained immense popularity in the field of ophthalmic screening due to their simple and easy photography functions. The use of smartphones could reduce referrals and their burden on main clinical centers due to the use of digital photography for non-diagnostic primary visits at peripheral centers.^[5]

Recently, smartphones have been used for microscopic confirmation of ocular surface and adnexal pathologies. Agarwal *et al.*^[7] used a smartphone and a pocket magnifier to diagnose fungal hyphae. Kaya *et al.*^[8] utilized a 90D lens attached to the smartphone to image and diagnose *Demodex folliculorum*; however, their imaging had low resolution. Prasher *et al.*^[9] have used a magnifying smartphone attachment and imaged fungal hyphae, demodex mites, and a corneal histopathological section. Chandrakanth *et al.*^[5] used four 30 dioptre IOLs and a smartphone to image fungal hyphae, larvae of parasites as well as histopathological sections. All the above-described innovative methods require the smartphone to be held using both hands to obtain a clear image or video of the specimen on the slide. In our technique, we have utilized the slit lamp as a stable platform for the movement of the IOLSCOPE to obtain high-resolution magnified images. The mechanical improvement we have devised is similar to that of a light microscope where a joystick is used for localizing the magnifying lens over the concerned region on the slide. The advantages of our apparatus include accurate placement

of the IOLSCOPE over the slide specimen or area of interest, the negation of minute hand movements that can occur while focusing onto the image, and utilizing one free hand to manipulate the smartphone touchscreen for focusing or magnifying the inbuilt camera. This setup gives impressive and clear pictures of the pathogen in the form of video and photographs, thereby helping in immediate diagnosis, appropriate treatment, patient education, and good patient compliance as they can see the videos or photos of the pathogen on spot during the examination. The digital zoom feature of the smartphone gives a better magnification of photographs, which can then be transferred to an experienced microbiologist for telemedicine.^[5]

Our novel technique that could convert any type of slit lamp into a microscope is an effective way of on-spot screening of doubtful infectious corneal ulcer cases to detect fungal hyphae and parasitic larvae identification [Fig. 3]. The main purpose of this setup was to provide a slit-lamp-based stable platform to obtain faster and clear microscopic images. This setup is especially advantageous in primary or secondary ophthalmic centers and even vision care centers where there is a lack of microbiological support. It can also be utilized by the paramedical staff with minimal training. Tele ophthalmological techniques can hence be made easily adaptable as well as accessible with the combination of secured message transmission, smartphones with good camera technology, user-friendly smartphone adapter, and an IOLSCOPE. Although the technique is important for rapid screening and diagnosis to initiate treatment, confirmation from microbiology and histopathology is required.

Conclusion

Hence, SLIM is an innovative novel modification to an already existing slit lamp to convert it into a microscope, especially useful in peripheral centers, vision centers, and local clinics for immediate screening and treatment of pathogens such as fungi and parasite larvae. It is a do-it-yourself, time-saving, a cost-effective setup, which can be adapted by any ophthalmologist or paramedical staff in their clinic for fast microscopic screening and treatment of microbial infections.

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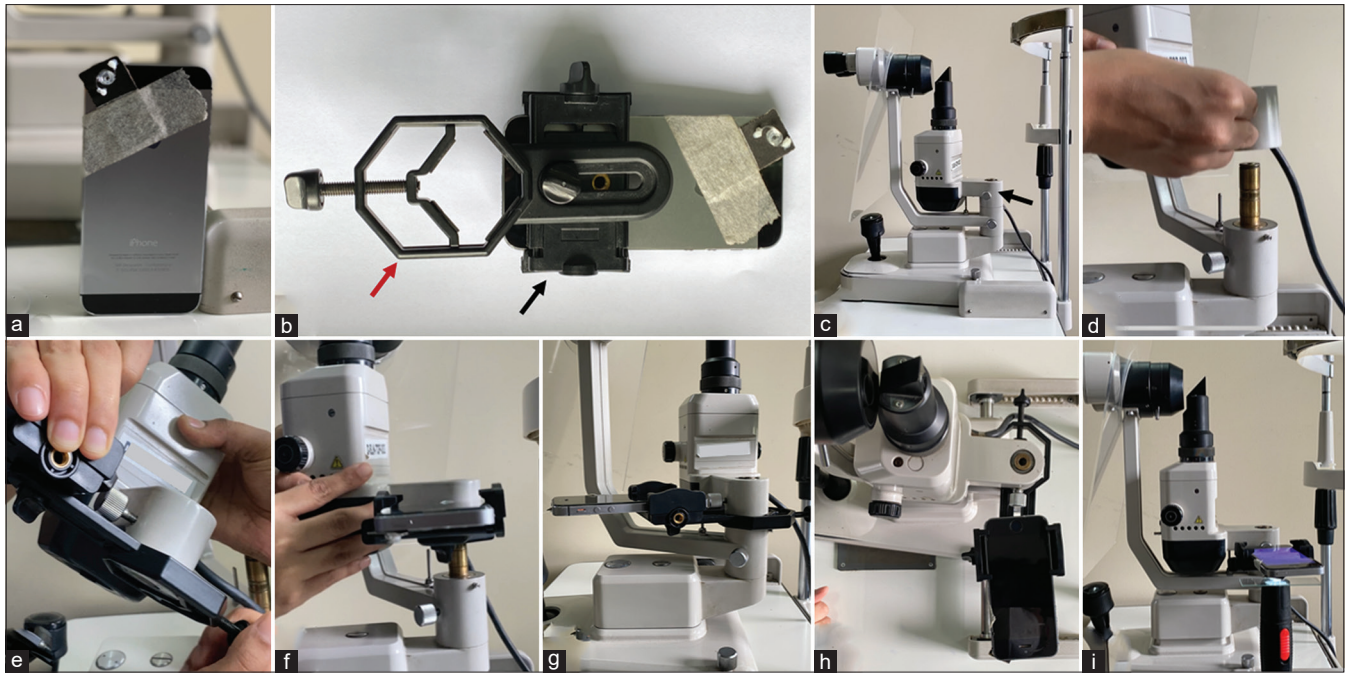


Figure 2: (a) IOLSCOPE with four IOLs stacked over the iPhone 5 camera; (b) Attachment of the IOLSCOPE to the mobile end of the adapter; (c) Arrow pointing toward the slit lamp co-pivot; (d) Dismantling of the illumination arm of the slit lamp; (e) Attachment of the slit lamp end of the smartphone adapter to the illumination arm; (f) Placement of the illumination arm of the slit lamp back on to the co-pivot mechanical arm; (g) Tightening of the screw of mechanical arm; (h) Superior view of SLIM assembly; (i) Lateral view of S.L.I.M ready for imaging microbiological or histopathological slides by moving the slit lamp joystick



Figure 3: (a) Lateral view of SLIM assembly with a different slit lamp model; (b) View from patient's perspective of SLIM; (c) Lateral view of SLIM being used to image a slide; (d) Superior view of SLIM being used to image a slide

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Conflicts of interest

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