

A Novel Slit-Lamp Adapter for Rapid, High Quality Ocular Imaging

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Abstract:

Background: Smartphones have become an essential tool for everyday use and have been incorporated assertively in the development of clinical practice; in the branches of medicine, it has become the main support for the documentation of audiovisual content for educational purposes, as well as a means for monitoring the clinical evolution of patients.

In ophthalmology, taking patients' ocular status faithful images has been a challenge in recent years, it has led to the development of multiple devices that are currently on the market which vary in performance and price. Due to this, we decided to incorporate a new adapter that integrates the smartphone and the slit lamp so that professionals can obtain clinically useful photos and videos in minutes.

Materials and Methods: We report the design of an adapter that integrates the slit lamp and the smartphone to obtain anterior segment images, assembled by dynamic support suitable for all types of smartphones and slit lamps, easy to install, and portable.

Results: The smartphone slit-lamp camera has many advantages: it is easily portable, commercially available, it can be used in any slit-lamp at any time and the ophthalmologist can use it for sharing records to other colleagues even in video call. Also it is simple and practical to use.

Conclusion: Nowadays the smartphone photography is something simple, secure and accessible for the vast majority of doctors, therefore the smartphone slit-lamp camera can be useful for healthcare staff to capture and share high quality anterior segment images.

Key Word: Slit lamp, adapter, photodocumentation, ophthalmology.

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I. Introduction

Ophthalmologists use anterior segment photo documentation to watch over progression of disease, documentation for case presentation and discussion, referrals to colleagues or subspecialty clinics and education for junior doctors and patients. In non-ideal clinical settings, such as in the emergency room, a smartphone can be used to document external photographs of the eye, slit-lamp pictures of the anterior segment, fundus biomicroscopy, and indirect ophthalmoscopy findings. We have also been successful in taking presentation-quality images and videos of surgical procedures through the operating microscope.⁽¹⁾

Image acquisition is particularly a problem in ophthalmology as the eye can only be examined thoroughly with expensive specialized optical instruments,⁽²⁾ a conventional slit-lamp camera is usually used for taking good quality pictures of the eye. The problem with slit-lamp cameras is that they are expensive and usually immobile.

Although most ophthalmology clinics are equipped with slit lamps, not all clinics are equipped with a high-quality anterior segment slit lamp camera, In addition, the complexity of the instrument together with the cost prohibits widespread use of it in remote communities. A portable and simplified instrument would be more suitable for the health-care in distant locations or minor resources clinics.⁽²⁾ Smartphones often incorporate high-resolution cameras that ophthalmologists often use to capture images of the anterior segment of the eye.⁽³⁾

Taking ocular imaging is of crucial use for ophthalmologists in their daily practice. As students, residents, educators and speakers, ophthalmologists often present clinical cases in conferences. The smartphone allows collection of acceptable quality presentation images for this purpose.^(4,5)

II. Material And Methods

There are several commercially available smartphone adapters to a slit-lamp but they are expensive and is specific for certain slit- lamp brands only.⁽⁶⁾

It is possible to mention a novel adapter smartphone for photo documentation of images of the anterior segment. Here are some of its distinctive features:

- Slit Lamp Adapter (SLA) can be adapted to any models of slit lamps and microscopes.
- The images can be made with any type of smartphone, which is easily adaptable to the SLA.
- Its innovative system allows the SLA not to occupy the eyepiece. The professional can observe the patient and when taking photos or making a video, he can rotate the phone and record the images he wants thanks to the patented hinge mechanism.
- It allows you to record the images and share them instantly with other professionals.
- The system is made of high quality materials with resistance and RoHS certification.
- It contains an installation kit and an explanatory video that is displayed through a QR code.
- Its installation is simple and fast. In less than 5 minutes the ophthalmologist can already be using it.

III. Result

Cost saving and maintenance

Conventional slit-lamp camera is an excellent alternative for quality image and video documentation but it is not accessible in most hospitals and institutions due to its high price. Furthermore, it requires to be serviced and maintenance needs to be done which incurs additional costs to the ophthalmologist.

On the other hand, the commercially available smartphone slit-lamp camera adapter ranges from several thousand dollars. It must be considered that these adapters have to be removed from the eyepiece to execute the physical examination and must be adjusted again at the time of documenting another finding, for this reason they are not considered practical in long hours of work.

Considering these disadvantages of other devices on the market, the SLA was developed to offer a solution to the gaps in efficiency and accessibility, maintaining an affordable price and easy installation without compromising image quality.

The estimated cost for this adapter is lower compared to others on the market and doesn't incur additional costs, by using the smartphone slit-lamp camera, there is virtually zero maintenance.⁽⁷⁾

Ease of use

Conventional slit-lamp camera is usually placed in a special room and not easily accessible but with the smartphone slit-lamp adapter, it can easily be used in any slit-lamp at any time. Patient will be explained of the anterior segment photography and consent will be taken.⁽⁸⁾

Most smartphones also have the ability to capture video. As mobile devices continue to integrate into ophthalmology, special consideration should be given to the Health Insurance Portability and Accountability act of 1996 (HIPAA) and patient confidentiality. While e-mail messages containing patient information and clinical photos can be sent securely with encryption, appropriate documentation of patient consent must be obtained. It should always be remembered that patient information must be protected and established guidelines adhered to.^(3,9)

Ease of Referrals

The most important benefits that the SLA gives to the professional are the possibility of sharing this record with other colleagues, even instantly through a video call. The comfort and practicality of carrying out inquiries, operations or live transmissions. Ease of documenting each procedure, recording in images everything that the professional sees and also providing each patient with a clearer explanation of their diagnosis through images, among other things.^(10,11,12)

The system can be used at times that the ophthalmologist deems necessary, and is in no way an interruption to the workflow. In addition, its simple and practical use is explained through an informative video that comes with the device, as well as the kit with everything necessary for its installation.

In any case, the SLA has an Assistance Service that will accompany the professional to resolve any doubts that may arise at the time of installation.

How to connect it?

The SLA is a digitalization system for ophthalmology that represents a necessary technological leap in quality for this important branch of medicine. The device is adaptable to all makes and models of slit lamps, microscopes and smartphones, and allows the professional to record and digitize the images of the procedures they perform in a simple, practical way and, most importantly, it does so without obstructing their workflow.

Take photos and videos in seconds with no additional setup required. Once installed, it works as one more accessory of the equipment, which allows the patient to be viewed and examined normally, without occupying the eyepiece.

The SLA unites technological innovation with simplicity, and represents an exponential improvement in the practice of ophthalmology both in the operating room and in the office. In addition, it is affordable, easy to use and its installation system allows it to be implemented quickly and efficiently, achieving better and faster results than devices that previously tried to fulfill this function. In less than 5 minutes the professional can be using the device.⁽¹³⁾

From the very beginning, the SLA was widely accepted and is still valid thanks to its ease of use and the important benefits it generates for the practice of the profession. Placing the smartphone vertically allows images to be recorded in the format necessary for publication on social networks (9:16 in the case of Instagram for Stories, Reels or TikTok), thus facilitating their dissemination.

How to use the smartphone slit lamp camera?

After mounting the adapter to the slit- lamp camera, one may use the built-in camera app in your smartphone and just snap pictures or video as desired. The camera flash should be disabled.⁽¹¹⁾

Zooming in/out: It is recommended to use the slit- lamp magnification for zooming in and out instead of the camera app as the quality of picture may reduce.

Background lighting: It is recommended to switch on the room lights during picture taking. The quality of pictures improves with some additional background lighting.⁽¹²⁾

Diffuser: Some slit lamps come with a diffuser which can be used to diffuse light if the ophthalmologist wishes to take pictures of the entire eye without slitting the light source. This gives a diffuse lighting to the eye.^(14,15)

AE/AF Lock: The picture quality may be increased by controlling lighting of the smartphone camera manually. AE (Auto Exposure) and AF (Auto Focus) lock enable the ophthalmologist to lock the exposure and focus only on specific locations and lighting needs. Quality of the pictures are comparable to the commercially available anterior segment camera.

Then, determine the focal point of your smartphone by placing the camera aperture directly opposite the eyepiece of the slit- lamp making sure that placement is centered. The distance between your smartphone and the eyepiece of the slit-lamp will be the focal length of your smartphone. The focal length for new model of iPhone is 1.0cm and the focal length Samsung is 0.75cm.^(5,16)





The settings described are applicable to most other slit lamps. Some settings require leaving the neutral density filter in place (ie, the neutral position for the filter arm on the illumination column); others require removing the neutral density filter (ie, the “bright” setting position for the filter arm on the illumination column). All the techniques necessitate holding the iPhone vertically and aligning the camera lens closely with one of the viewing pieces from the slit lamp biomicroscope. While this is being done, the image should be viewed on the iPhone screen. Small vertical or horizontal adjustments to the position of the iPhone can easily be made to bring the image into view on the screen. The other hand can be used to focus and align the slit- lamp and, if necessary, hold the patient’s eyelids open.^(7,17,18)

Although the technique described might be applicable to other mobile phone camera devices, for example the capture button is integrated into the display screen below the image and is touch sensitive, allowing the image to be captured with one hand.

Images obtained with the above technique have been used at our departmental rounds and are of sufficient quality to be projected for an audience. Moreover, recent improvements in the iPhone have increased the resolution of the digital camera from 12 megapixels and record video at 4k, 8K and 60 fps.^(19,20)





Furthermore, the software on the iPhone allows anonymized images to be easily sent electronically, as MMS messages or email attachments, for tele ophthalmology. Finally, although we did not use special applications for capturing images, such applications exist and might facilitate capturing, cropping, and editing images.⁽²¹⁾ (Figure 1 A, B, C, D, E, F) shows the versatility as well as the quality of images produced with this technique.

How to install

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|  <p>Figure 1. Step 1: Remove the magnetic plates from the bracket, the two screws and Allen key.</p> |  <p>Figure 2. Step 2: Set the interpupillary distance, place the SLA in the eyepiece.</p> |
|  <p>Figure 3. Step 3: Set the interpupillary distance, place the SLA in the eyepiece.</p> |  <p>Figure 4. Step 4: Take the magnetic plate and place it inside the smartphone case and then on the SLA.</p> |

Fine tuning steps

How to set camera focus with these simple steps:

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|--|--|
|  <p>Figure 5. Loosen the top screw with the Allen key.</p> |  <p>Figure 6. Move the plate to your SLA to focus the camera and check if the focus is correct.</p> |
|  <p>Figure 7. Retighten the upper and lower screws with the Allen key.</p> |  <p>Figure 8. It is ready for use!</p> |

Ocular Imaging:



Figure 9. Bacterial ulcerative keratitis due to *S. Aureus* in a patient with ocular rosacea.



Image 10. Conjunctival squamous cell carcinoma in situ.

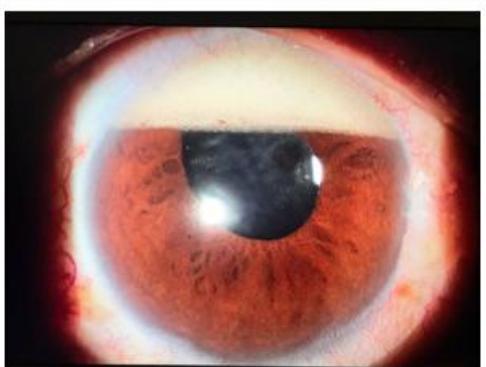


Figure 11. Silicon emulsified in the anterior chamber (inverted hypopyon).



Figure 12. Neuroretinitis due to *B. Henselae*.

IV. Conclusion

In this era, most medical doctors are equipped with a smartphone which can help us not only in our daily lives but also in our work. Smartphone photography is something simple and yet very useful in the world of ophthalmology.

The combination of secure message transmission, smartphones with cloud access and high quality camera technology, and a user-friendly, an adapter to easily couple to a smartphone are now making tele ophthalmology increasingly accessible.

Our ultimate goal is for this system to be usable by healthcare staff with minimal specialized training to remotely capture and share high quality anterior segment images in order to enhance healthcare provider communication.

In future work, we plan to deploy subsequent generations of the adapter to non-ophthalmologists to evaluate their potential use in developing nations, inpatient consults, and areas where access to an ophthalmologist is limited.

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