SMARTPHONE-BASED OCULAR PHOTOGRAPHY

Pointers for shortening the learning curve and improving image quality.

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In today’s digital world, smartphones have become ubiquitous, indispensable, sophisticated tools. These devices are revolutionizing medical care, and they have found numerous novel uses within ophthalmology. Although light sources have the potential to be harmful to the eyes, studies have shown the photobiological safety of smartphone-based ocular photography to be within the safety limits of thermal and photochemical hazards as defined by the International Organization for Standardization.

To date, the most established ophthalmic uses are funduscopy and telemedicine applications for retinal diseases, but smartphones have great potential to transform multiple aspects of eye care. The use of smartphone-based ocular photography can facilitate ophthalmic training and improve diagnostics, although inconsistent results and the associated technological learning curve have limited the use of this practice. With proper technique and guidance, however, these inconsistencies and limitations can be overcome. This article is specific to our experience with the iPhone (Apple), but several of the pointers discussed here apply to the use of any smartphone device.

**BUILT-IN SMARTPHONE CAMERAS**

Older generations of the iPhone feature a single-camera system, whereas newer models feature a dual-camera system. In our experience, the dual-camera system on the newer iPhones X and 11, in combination with updated processors (Apple A11 Bionic and Apple A13 Bionic) and optical image stabilization, provides significantly better image results.

In general, smartphones that offer optical magnification and image stabilization can capture sharper, higher-resolution images than devices without these features. We conducted a pilot study to compare image quality with the iPhone 6s versus the newer iPhone X, and we observed significantly better results with the dual-camera system on the iPhone X (Figure 1).

**ADDITIONAL LENSES**

Additional lenses can be used with smartphones to add varying degrees of image magnification and improved image resolution. The Volk 20D lens (Volk Optical)—a common tool in the clinic—is a valuable aid for fundus and anterior segment photography, as it supplies 3x image magnification.

There are also clip-on lenses that can be attached to a smartphone to add magnification capabilities to the camera’s optics. These lenses, available in a range of magnification powers, decrease the camera’s minimum focusing distance, thereby allowing the user to decrease the distance between the ocular surface and the smartphone camera. We have found that a 10x macro lens is adequate for photographing most details of the ocular surface. In specific cases, such as when a particular pathologic lesion needs highlighting, a higher-magnification lens can be used. However, it is important to keep in mind that the greater the magnification, the smaller the field of view.

**IDEAL ILLUMINATION**

Illumination plays a vital role in image quality. The camera setting responsible for controlling the brightness of an image is called ISO. Inadequate illumination necessitates the use of a higher ISO in order to achieve proper image exposure. However, when the ISO is increased, significant detail is lost and digital noise is added. Ideal illumination, therefore, provides enough exposure to retain high detail in areas of interest without adding digital noise, and yet not so much as to cause over-exposure and highlight clipping, or loss of details in the highlights of the image.
Close, intermediate, or distant illumination. Changing the distance between the light source and the ocular surface dramatically affects image lighting. In our study, we found intermediate illumination to be ideal for smartphone-based ocular photography.

Source and hue. The hue of the light source—whether an external light or the built-in flash on the iPhone—also affects image quality. In our experience, a yellow-light pen torch is ideal for most ocular scenarios and produces the most natural-looking images. A white-light pen torch may produce better results when visualization of blood vessels is a priority.

CAMERA APPS

Native app. The built-in camera app on the iPhone has advanced over the years. With this app, the user can touch the iPhone screen to adjust focus and exposure. The user can also touch and hold the screen to lock the focus and exposure settings (Figure 2).

Third-party apps. Precision control of all parameters (focus, ISO, shutter speed) of a camera enables fine-tuning of an image to achieve the desired visual result. Third-party apps are more complex than native smartphone camera apps, and they carry higher learning curves. However, these apps can produce more consistent and easy-to-replicate results, as their parameters can be manually preset to desired settings. One third-party app that has been extensively used and studied in the ophthalmic literature is Filmic Pro (Cinegenix).²

PRACTICE

As with any task, smartphone photography improves with practice. Tips to keep in mind while practicing are listed below.

► No. 1: Use steady hands. The image stabilization feature on newer iPhone models makes it easier for users to attain shake-free images than with older models. In using devices without this feature, it is essential that steady hands be maintained during image capture. Doing so reduces the possibility of introducing motion blur to the image, with resulting loss of sharpness and detail.

► No. 2: Get comfortable with the equipment. With any new piece of equipment, the user must grow accustomed to the product before he or she can become truly proficient and efficient in its use.

► No. 3: Nail the focus. With the camera app open, tap the iPhone screen to focus the image, and tap and hold the screen to lock the focus and exposure. Drag downward or upward to adjust the image exposure. Once the focal plane is locked, moving backward or forward will produce a blurry image. Therefore, it is essential to use steady hands and keep the focal point on the area of interest.

► No. 4: Compose the image. Photography enthusiasts are experts in image composition, often nailing the golden ratio and rule of thirds. However, with smartphone-based clinical photography, the user must often go through some trial and error before he or she can properly frame an image to the desired result. Image composition becomes more complex with additional lens attachments. With the 20D lens, it is essential to align the lens and the smartphone camera lens coaxially and closely, and to then increase or decrease the distance between the eye and the lens-smartphone complex to obtain an image that is sharp and in focus. With a clip-on lens attachment, caution must be exercised that the lens does not touch the patient’s eye.

► No. 5: Use effective communication. When the photographer or clinician explains the smartphone photography exercise to the patient, he or she should give clear directions regarding how the patient can help to produce the best image. Effective communication helps to minimize blink reflex, improve patient compliance, and reduce discomfort.

► No. 6: Seek assistance. It is often helpful to have an assistant help position the patient, adjust the illumination source, and lift the patient’s eyelid. This allows the operator to focus his or her attention on capturing the image.

Quick Tips for Smartphone Photography

1. Use steady hands
2. Get comfortable with the equipment
3. Nail the focus
4. Compose the image
5. Use effective communication
6. Seek assistance

Figure 2. With a native smartphone camera app, the user can adjust the focal point and exposure by tapping on the screen.
on successfully capturing the clinical images.

**CONCLUSION**

In our practice, we use smartphone photography not only to assess the fundus in an emergency setting but also to capture images of the anterior segment. We also recently started documenting vascular changes in the bleb area during the postoperative course of trabeculectomy. Of course, the utmost regard is given to patient consent and confidentiality, and data transfer is done using message encryption.

As smartphone devices become more advanced over time, their photographic capabilities will continue to improve, offering even more value to the ophthalmologist user.