

# Recording and viewing stereoscopic ophthalmic surgical videos with smartphones

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## ABSTRACT •

**Objective:** To determine whether stereoscopic footage of cataract surgery could be captured with smartphones and to develop a procedure for editing and viewing the footage. The authors sought to measure whether subjectively convincing stereo footage could be captured with smartphones, whether it would be possible to sync this footage for stereoscopic viewing, and whether these tasks could easily be performed at lower cost than commercially available options.

**Design:** Brief research report.

**Participants:** The entities studied were phones and programs.

**Methods:** Surgeries were recorded at Fort Belvoir Community Hospital. Two smartphones were attached to the eyepieces of a surgical microscope's assistant scope. Surgical footage was recorded. Videos from the left and right eyepieces were edited and combined into videos that facilitated stereoscopic viewing.

**Results:** Stereo footage was captured with 2 smartphones and edited to enable 3D viewing with both anaglyph glasses and head-mounted displays. Viewing experience was superior when using head-mounted displays compared to using anaglyph glasses.

**Conclusions:** Stereoscopic footage of operations performed under the surgical microscope may be captured and viewed using inexpensive equipment and simple procedures requiring minimal prior expertise. The techniques described in this paper may enable more training programs to capture and distribute 3D footage of their operations, enhancing the educational value of ophthalmic surgical videos.

Smartphone qualities, including processor speed, screen resolution, camera lens, and charge-coupled device sensor, are rapidly improving even as the adoption of these devices increases in medicine and surgery, with recent survey data suggesting that more than 90% of doctors use smartphones.<sup>1</sup> Rapid adoption of these new technologies has occurred with vigor in the field of ophthalmology.<sup>2</sup> A recent review found that out of 621 surgery apps in the iOS App Store, over 120 were dedicated ophthalmology apps,<sup>3</sup> now including “The Wills Eye Manual,” ophthalmic translation guides, and other education resources.<sup>4</sup> Although a Fred Hollows lecture in 2000 lamented the “expensive, barely portable” nature of high-resolution digitized imaging equipment,<sup>5</sup> ophthalmologists have recently explored the potential for smartphone devices to facilitate low cost, presentation quality, portable funduscopy,<sup>6–10</sup> retinoscopy,<sup>11</sup> fluorescein angiography,<sup>10,12</sup> postoperative toric intraocular lens alignment measurement,<sup>13</sup> anomalous head posture measurement,<sup>14</sup> slit-lamp photography,<sup>4,15</sup> and surgical recording.<sup>4,15</sup>

Smartphone technology can make capturing and sharing data easier and more efficient, enabling telemedicine with patients and colleagues.<sup>16</sup> One means of sharing educational information is through videos of surgery. Unfortunately, these videos are inferior to sitting at the surgical microscope, which affords a binocular view of the operating field. Although surgical technology companies have developed hardware and software for 3D surgical

recording, these resources may be prohibitively expensive. Lower cost solutions have been tried. One neurosurgery team described using a commercially available adapter for 2 GoPro (San Mateo, Calif.) units in over 50 cranial and spinal surgeries to create a library of educational 3D videos.<sup>17</sup> Ophthalmologists have employed GoPro cameras in similar fashion to capture stereoscopic footage of scleral buckling procedures.<sup>18</sup>

Given recent developments in smartphone screens and the use of smartphone cameras to record at the operating microscope, the authors thought it would be possible to capture and view stereoscopic recordings of surgery with smartphones.

## METHODS

### Recording

The first step in creating 3D video is capturing footage from 2 perspectives. Recording devices should be similar or identical to avoid discrepancies in frame rate, resolution, aspect ratio, and format that would require conversion and possibly result in distortion. The authors recorded videos with 2 iPhone 5S (Apple Inc, Cupertino, Calif.) smartphones, each using the ProCamera app (Cocologics GmbH, Mannheim, Baden-Württemberg, Germany). This app was selected for its tiltmeter function and because it allowed for easy selection of a focal point. Video was recorded at 1920 × 1080 p resolution at 30

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frames per second. The iPhones were attached to the surgical microscope eyepieces with Magnifi (Arcturus Labs, LLC, Palo Alto, Calif.) adaptors. The authors that found recording with cameras oriented horizontally facilitated video editing.

Cameras were oriented using the level tool in the native Apple Compass app and ProCamera's tiltmeter function, as seen in Figure 1. Recordings were accomplished with the smartphones in horizontal and vertical orientations, as seen in Figure 2. Steps for setting up the smartphones and recording are described in Table 1.

## Editing

*Part A: Syncing.* Recorded footage must be trimmed to have an identical number of frames, synced with respect to time, and converted to a format enabling stereo viewing. Although it may be easier to edit video with professional-grade software such as Adobe Premiere (Adobe Systems, San Jose, Calif.), Sony Vegas Pro (Sony Corp, Minato, Tokyo, Japan), or Final Cut Pro (Apple Inc), the authors used free software to edit video to demonstrate the effectiveness of low-cost solutions.

The first step in editing is to determine the difference in total number of frames between the right and left recordings. The authors used a free audio video interleaver (AVI) demultiplexer program called AVIdemux to display the length of recorded videos. The number of frames in each video was calculated, and extra frames were trimmed so that both videos contained the same number of frames.

Even if 2 videos contain the same number of frames, they may not be in sync. Frames were trimmed from the beginning or end of the longer video to bring the videos into sync. The procedure used to trim and sync videos is explained in Table 2 and further illustrated in Figures 3, 4, and 5.

*Part B: Combination.* Next, the left and right videos are combined. Myriad formats have been created for stereo viewing. For the sake of brevity, 2 popular formats are discussed: anaglyph and side-by-side. Procedures for

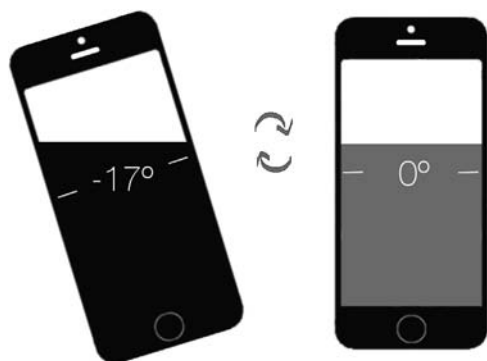


Fig. 1—The level tool within the iPhone compass app may be employed to orient the smartphone cameras.

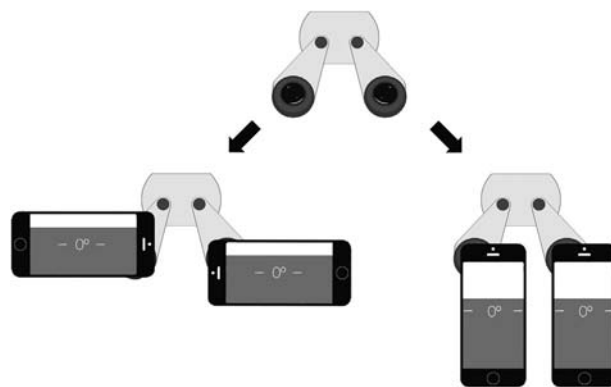


Fig. 2—Smartphones may be positioned in vertical or horizontal orientation. The authors found recording with cameras oriented horizontally facilitated video editing.

creating side-by-side videos using free software are outlined in Tables 3<sup>19</sup> (Windows) and 4 (Mac). Procedures for creating anaglyph videos may be found in Appendix A.

## Viewing

*Anaglyph.* Anaglyph video may be viewed with red/cyan filter glasses (the red filter should cover the left eye). Red/cyan filters were chosen because a group of researchers investigating crosstalk found that red/cyan filters were associated with minimal crosstalk compared with red/green and blue/yellow anaglyph glasses.<sup>20</sup>

*Side-by-side.* Side-by-side video may be viewed on a variety of head-mounted displays (HMDs). The market for HMDs is growing as “virtual reality” devices are developed by Samsung, HTC, Oculus VR (owned by Facebook), Sony, and others. One of the least expensive options is Google Cardboard (Google Corp Mountain View, Calif.), Cardboard was tested with a Samsung Galaxy S4 (Samsung Group, Suwon, South Korea), which has a

Table 1—Steps for recording surgical video with smartphones

Step 1	Open the Compass app (pre-installed on every iPhone and cannot be removed) on each iPhone, and after the initial calibration is complete, swipe to the right to activate the level tool.
Step 2	Disinfect iPhone and adaptor surfaces with a germicidal wipe.
Step 3	With the Magnifi adaptors, connect the iPhones to the left and right eyepieces of the assistant microscope.
Step 4	On each device, open the ProCamera app and check for an adequate field of view for each iPhone. Activate the tiltmeter tool using the menu in the bottom right-hand corner of the app. Adjust manually as needed until each phone has a good view of the center and adequate view of the periphery as seen from the exit pupils of the surgical microscope.
Step 5	On each device, open the Compass app and use the level tool to orient each phone to 0°.
Step 6	After the patient enters, the surgical field is prepped, and the microscope is adjusted to its operating position, repeat step 5 and confirm proper orientation by ensuring that the vertical line of the ProCamera tiltmeter is green.
Step 7	Begin recording before or at the start of the surgery.
Step 8	Halt recording at a judicious time after the case concludes.

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