

Addressing the concerns of aerosolization during phacoemulsification due to COVID-19: human cadaveric eye with trypan blue



COVID-19 is a severe respiratory illness caused by the new coronavirus, SARS-CoV-2. The virus has been shown to be transmitted through fomites, droplets, and aerosols.^{1,2} The SARS-CoV-2 virus has been isolated from conjunctival swabs of infected individuals.^{3,4} There are concerns among ophthalmologists regarding whether the rapid oscillations of the phacoemulsification probe could generate aerosols. To evaluate this concern, we conducted a series of experiments that can be viewed at <https://cataractcoach.com/2020/05/28/does-cataract-surgery-pose-a-viral-risk/>. For each experiment, we used a human cadaveric eye, a 2.2 mm clear corneal incision, and a 2.2 mm phacoemulsification sleeve and, using a Centurion phacoemulsification machine (Alcon), evaluated both longitudinal and torsional phacoemulsification modalities. At the beginning of each experiment, we filled the anterior chamber with trypan blue dye to simulate viral aqueous and allow for easy visualization.

For experiment 1, after creating our corneal wounds and injecting trypan blue into the anterior chamber, we performed irrigation and aspiration of the anterior chamber fluid with a sleeved irrigation/aspiration tip. Theoretically, doing this for 6 to 10 seconds should be adequate to remove the volume of aqueous in the anterior chamber. As seen in the video, the viral fluid is successfully removed from the eye without the creation of aerosols. Next, we injected ophthalmic viscosurgical device (OVD) into the eye and proceeded with longitudinal and torsional phacoemulsification independently. Again, no visible aerosols were produced, either with microscope or side filming views. The surgeon's hands remained dry the entire time, as did the microscope. Therefore, performing irrigation and aspiration at the start of the case is shown to effectively evacuate the anterior chamber volume. Furthermore, after formation of the anterior chamber with OVD, no trypan blue was seen to be aerosolized during phacoemulsification.

For experiment 2, we injected trypan blue into the anterior chamber after creating corneal incisions to mimic viral aqueous. We then displaced the viral aqueous with OVD prior to introducing our phacoemulsification probe. In this experiment, we did not perform irrigation and aspiration to start the case. The OVD successfully displaces the viral aqueous out of the eye without aerosol creation. Neither longitudinal nor torsional phacoemulsification created visible aerosols, as seen in the video.

Experiment 3 was used as a control to demonstrate that applying phacoemulsification to an open sky model does

create a visible plume. Furthermore, trypan blue was visible on the surgeon's gloves; this did not occur in either experiment 1 or experiment 2.

In our series of experiments, we demonstrated 2 methods of performing phacoemulsification in a human cadaveric eye without the production of aerosols. Although no studies to date have analyzed whether SARS-CoV-2 is present in the aqueous humor, it has been isolated on the conjunctival surface, and other viruses have also been isolated from the aqueous humor.²⁻⁴ Povidone-iodine solutions are routinely used to disinfect the surface of the eye prior to cataract surgery. Povidone-iodine solutions have been shown to have highly effective virucidal activity against a broad range of viruses, including coronaviruses such as SARS-CoV-1 and MERS-CoV.^{5,6} This virucidal activity likely extends to the new coronavirus, SARS-CoV-2. The rate of aqueous humor production is $2.4 \pm 0.6 \mu\text{L}/\text{min}$.⁷ By comparison, conventional aspiration rates (20 to 40 mL/min) during cataract surgery are 3 to 4 orders of magnitude greater. Therefore, once the initial aqueous humor from the anterior chamber has been evacuated (either through initial irrigation and aspiration or by displacement with OVD), the rate of viral accumulation in the anterior chamber would be exceedingly low during the surgery. Darcy et al. demonstrated that phacoemulsification tip size can affect the production of aerosols.⁸ They found that, although aerosols were created by a 2.75 mm phacoemulsification tip, there were no visible aerosols created when using a 2.2 mm tip. They also found that coating the surface of the cornea with an OVD can block aerosols; however, this effect was short-lived.

Removal of aqueous humor either with irrigation and aspiration or by displacement with OVD at the beginning of the case is sufficient to remove potential viral particles from the anterior chamber without the production of aerosols. Longitudinal and torsional phacoemulsification modalities with a 2.2 mm tip do not generate significant aerosolization. We also recommend the continued use of povidone-iodine to sterilize the conjunctiva and ocular surface as per regular protocol.

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