

## Novel device to contain aerosols during phacoemulsification

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We herein describe a novel device to contain droplets and aerosols during phacoemulsification. We modified the silicon phaco test chamber into an aerosol containment chamber (ACC) by shortening the chamber and making a pear-shaped opening at one aspect of its tip. The ACC was fitted over phaco tip such that 4-5 mm of phaco tip and sleeve was exposed. When the phaco tip and irrigation port are inside the anterior chamber during phacoemulsification, the portion of the modified chamber remains around the clear corneal tunnel in an enclosing manner that contains aerosols and droplets.

**Key words:** Aerosol containment chamber, aerosols during phacoemulsification, COVID-19, novel device, SARS CoV2

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Aerosols have been cited to be a mode of transmission of SARS CoV 2 causing the COVID-19 pandemic, and health care professionals are at constant risk of exposure to aerosols. Aerosol transmission of Mycobacterium Tuberculosis and viruses like SARS coronavirus, Nora virus, Ebola virus were also noted in the literature<sup>[1]</sup> and all these infectious agents infect conjunctiva.

Various studies have analyzed the formation of aerosols during phacoemulsification.<sup>[2,3]</sup> Some studies have demonstrated aerosol formation, while other studies provide contradictory data.<sup>[4]</sup> The latter have not commented about the visualisation of particles of size less than 20 microns.

Technique of fitting semi-transparent drapes around microscope is advocated during phacoemulsification to create a large physical barrier to contain aerosols.<sup>[5]</sup> We have developed a small novel physical device to contain visible and invisible aerosols at the site of its source during phacoemulsification, in an effort to create small and effective barrier.

Our objective was to analyze a viable and cost-effective innovative device to contain aerosol during phacoemulsification.

### Technique

Approval was obtained from the Ethics committee and the tenets of the Declaration of Helsinki were adhered to.

The phaco test chamber was modified into an aerosol containment chamber (ACC). It was used along with the phaco probe to contain aerosols during phacoemulsification.

The Phaco silicon test chamber is used for priming, tuning and testing the vacuum build-up prior to the actual phacoemulsification. It consists of a soft flexible proximal and a rigid distal portion. The length of the test chamber was modified such that the rigid portion was 10 mm long. A pear-shaped opening was made at the proximal end of test chamber. To get appropriate pear-shaped opening, a 3 mm corneal trephine was used to make a circular opening after inserting the swab stick into the tube. The circular opening was made at one aspect of the tip, starting from mid-point of the tip. It was then converted to a pear shape opening of 4 mm length using conjunctival scissors. Considering the width of the clear corneal tunnel and to-fro movement of phaco tip during phacoemulsification, the ideal dimensions of pear-shaped opening was concluded to be of 4 mm length and 3 mm maximum width [Fig. 1].

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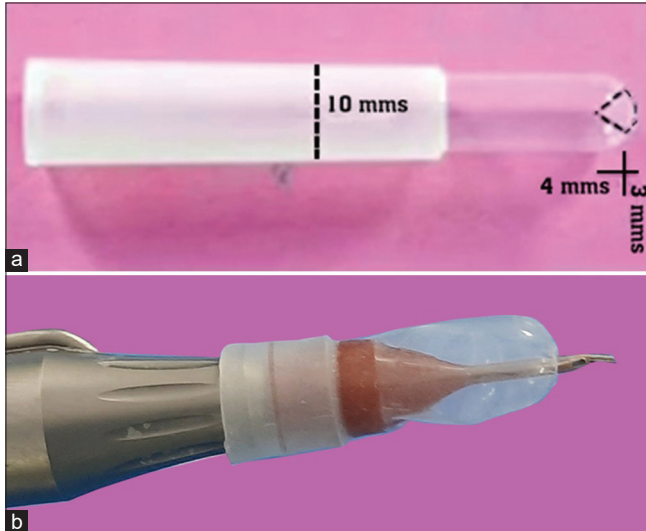
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The ACC was fitted over phaco tip and sleeve such that approximately 4 mm portion of phaco tip and sleeve would be exposed out of the ACC [Fig. 1]. When the exposed phaco tip and sleeve were inserted inside the anterior chamber, a portion of the ACC was over the clear corneal tunnel in an enclosing manner which acts as a containment chamber to filter aerosols and droplets [Fig. 2]. Subsequent steps of phacoemulsification were performed routinely.

To know the efficiency of the APC it was used in 2 Phases.



**Figure 1:** (a) Shows dimensions of manual opening and length of the chamber. (b) Shows Aerosol containment chamber fitted over phaco probe before starting phacoemulsification

## Results

### Phase 1 - Wetlab study done with goat's eye

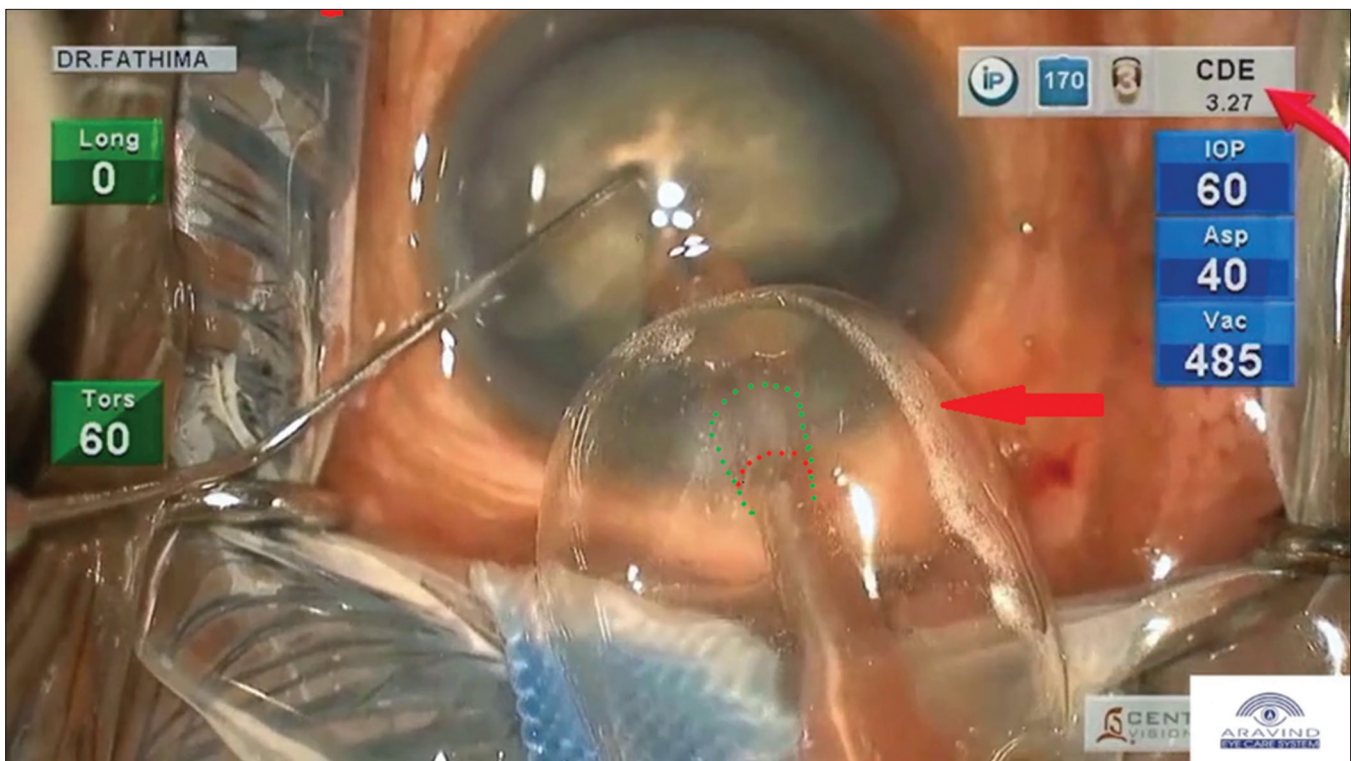
Phacoemulsification was performed through 2.8 mm tunnel in goat's eye and presence of droplets and aerosols were noted, whenever ultrasound energy was delivered [Video 1]. The droplets and aerosols were captured by using slow-motion video support for 1080p at 240 frames per second in iPhone 11.

The ACC was fitted over the phaco probe and phacoemulsification was performed through the same tunnel. When ultrasound energy was delivered at the same setting and video was taken with the same mode, it was observed that ACC effectively contains aerosols and droplets within its chamber. There were no droplets and aerosols detected outside its chamber.

### Phase 2 - In human eye phacoemulsification

A dry ACC was fitted over phaco probe as mentioned earlier and phacoemulsification was performed routinely. There was collection of fine air bubbles along the inner wall of the chamber [Fig. 2], whenever ultrasonic energy was delivered [Video 1]. These bubbles indicate precipitation of aerosols along the inner wall of the ACC. The amount of fine bubbles formed was proportional to the amount of ultrasound energy and grade of cataract.

The ACC device was used during phacoemulsification in 223 eyes with varying grades of cataracts excluding patients with posterior polar cataracts. Posterior capsular tear occurred in 2 cases of advanced nuclear cataract which were managed with anterior vitrectomy and sulcus placement of multi-piece IOL. No complications were noted because of ACC like epithelial



**Figure 2:** Red dotted line indicates the site of corneal entry wound; Green dotted line indicates opening made in ACC that covers the corneal wound in an enclosing manner Red arrow shows accumulation of fine bubbles inside the chamber indicating deposited aerosols

defects or wound burns, as it is made of soft silicon material. And also there was no interference in the visibility of surgical field.

## Discussion

Aerosol formation during phacoemulsification was demonstrated in the model set up<sup>[2]</sup> as well as in human corneoscleral cadaveric rim fitted over artificial chamber<sup>[3]</sup> except in tightly made wounds.

Another study had mentioned that no visible aerosol was generated during phacoemulsification. But this study did not include particles of size less than 20 microns and invisible aerosols into consideration.<sup>[4]</sup> It is understood that even high-resolution cameras can detect only particles of size more than 10 microns.<sup>[3]</sup> But, the SARS-CoV-2 aerosols were mainly found to include two size ranges, one in the sub-micrometer region (dp between 0.25 and 1.0  $\mu\text{m}$ ) and the other in super micrometer region (dp >2.5  $\mu\text{m}$ ).<sup>[6]</sup> The World Health Organisation defines aerosols as particles of size less than 5 microns.<sup>[7]</sup> With extensive literature search, we couldn't find direct evidence for absence of aerosols of less than 5 microns during phacoemulsification. Hence we recommend to use this ACC during phacoemulsification.

While comparing 2.2 mm and 2.75 mm phacotip, visible aerosols were observed in the latter.<sup>[2]</sup> Many surgeons adopt 2.8 mm incision either because they are not comfortable with 2.2 mm incision or they work with basic phaco machines, which do not have the facility of micro-incision phaco (2.2 mm). Moreover in routine practice, 2.75 mm phaco tip is used in 2.8 mm tunnel.

So in many instances, there is chance of leakage of minimal fluid from the anterior chamber, which could be aerosolized while phaco energy is delivered (25 KHz-100 KHz).

We do agree that aerosols formed during phacoemulsification may be from the leaking balanced salt solution (BSS). Evidences support that SARS coronavirus 2 is highly contagious with viral shedding in tears and ocular secretion of infected individuals even when they are asymptomatic.<sup>[8]</sup> Hence, there are chances for the virus particles to get mixed up with the leaking BSS and get aerosolized, risking the health care personnel in the operating room.

The technique of attaching semitransparent drape around operating microscope which creates a large physical barrier between the surgeon and patient's eye is advocated during phacoemulsification.<sup>[5]</sup> But this large physical barrier could cause inconvenience while handling or changing instruments and it may get disturbed during surgery and also during removal of the drape which could permit potential mixing up of aerosols into operating room atmosphere. Our ACC helps to overcome this disadvantage by containing aerosols at the site of its source. Moreover, these drapes cannot be reused and thus need to be disposed after each use, whereas ACC can be decontaminated by dipping into 10% Povidone Iodine immediately after use and later it can be sterilized and reused multiple times. Thus ACC effectively reduces the usage of non-biodegradable material.

In general, Particulate matter (PM) of size less than 10 microns including aerosols can be deposited by dry and wet methods. Dry deposition happens with PM of 10 microns,

whereas wet deposition happens more in cases with PM of 2.5 microns.<sup>[9]</sup> In our set up, the ACC acts as a solid obstacle and induces impaction and dry deposition. There is also accumulation of thin film of fluid within the chamber due to capillary suction, which provides wet surrounding allowing incorporation of aerosols into the fluid through impaction. This leads to wet deposition.

Diffusion of submicrometre aerosol particles leads to coagulation with adjacent aerosols due to Brownian motion resulting in formation of macro size bubbles.<sup>[10]</sup>

Hence our plausible evidence is the accumulated fine bubbles that we noted inside the ACC [Fig. 2], could be coagulated agglomeration of aerosols or precipitated droplets. In the case of precipitated droplets, if not contained effectively, it can evaporate in a fraction of second in the atmosphere and lead on to droplet nuclei which can suspend in air for longer duration.<sup>[10]</sup> Hence we recommend to use this device during phacoemulsification.

Lee *et al.* had measured particles using particle counter in a laboratory and concluded that phacoemulsification does not produce aerosols with hydroxyl methyl propyl cellulose (HPMC) over the surface.<sup>[11]</sup> But, HPMC can easily flow off from the surface of the tunnel due to maneuvering of phaco tip. One cannot be sure how frequently it has to be applied because the retention time of HPMC over the tunnel differs during surgical maneuvers. Hence our ACC can be filled with HPMC and used as mentioned earlier to provide a continuous supply of HPMC at the tunnel.

## Limitation

If the opening is made larger than the dimensions recommended in this study, this device can interfere with the visibility of surgery. If a custom made similar device is developed with appropriate size opening and reduced dimensions, it would overcome this limitation.

## Conclusion

We recommend the use of ACC during phacoemulsification, to create safer operating room for health care professionals, whenever outbreak of infectious diseases with chances of aerosol transmission occurs.

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## Conflicts of interest

There are no conflicts of interest.

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