Slit lamp examination during COVID-19: Where should the protective barrier be?

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Purpose: The aim of this study was to describe a poly-vinyl chloride air condition (PVC AC) curtain shield placed at the intervening space between the chin rest and the illuminating and optical arm of the slit lamp microscope (distal barrier) instead of the present position at the oculars (proximal barrier) to guard against severe acute respiratory syndrome Coronavirus 2. This experimental study was done to validate and compare the protection offered by the conventional breath shields and the one described by us in a simulated environment. Methods: In this experimental study, 12 puffs of fine mist were sprayed over a period of 1 minute using “magenta-colored dye” and “cyan-colored dye” for analyzing proximal barrier and distal barrier respectively. To access the amount of contamination of the slit lamp, caused by sprayed “magenta” and “cyan” colored dye, we covered the entire slit lamp with appropriately sized white-colored cotton sheet. The stained sheets were individually photographed and then the images were first cropped, then color threshold adjusted and then converted to binary and finally fraction of surface area stained was calculated using the Imagej software. \( P_{\text{Surface Area}_{\text{magenta fraction}}} \) and \( P_{\text{Surface Area}_{\text{cyan fraction}}} \) during analysis of “proximal barrier” and “distal barrier”, where \( P \) refers to various parts of slit lamp. Results: The entire surface area of the cloth covering the slit lamp was 9912.45 cm². The surface area of the cloth which was stained when using the “proximal barrier” was 567.50 cm² whereas when using the “distal barrier” was 222.93 cm². When using proximal barrier, 97.71% of the staining was present on the slit lamp base, viewing arm, illumination arm and the pivot of the slit lamp. While using the distal barrier shield no parts of the viewing arm, illumination arm, the pivot or the mechanical base with joystick were stained. Conclusion: The novel PVC AC curtain shield provides better barrier against the simulated contaminated stream of patient’s breath directed towards the working parts of the slit lamp as compared to conventional slit lamp oculars mounted breath shields.

Key words: Breath shields, COVID-19, distal barrier, parts of slit lamp, proximal barrier, slit lamp examination, transmission

The spread of Coronavirus Infectious Disease 2019 (COVID-19) is caused by severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2), via respiratory droplets has been confirmed. Under hospital settings the spread of COVID-19 can occur in the following scenarios:

1. Airborne transmission in setting of aerosol-generating procedures (AGPs). These include positive-pressure mechanical ventilation, tracheal intubation, chest physiotherapy, nebulizer treatment, sputum induction and bronchoscopy, procedures performed in ICU or OT settings.

2. Droplet contamination: Respiratory droplets generated by coughing, sneezing, or talking, are large particles, having a diameter greater than 5 µm. These do not remain suspended in the air for long, fall to the ground rapidly after being produced and are usually dispersed over short distances. Transmission can occur directly when these respiratory droplets reach susceptible mucosal surfaces, such as in the eyes, nose or mouth.

In the present times of COVID-19 pandemic, the proximity of an ophthalmologist to the patient during slit-lamp examination along with the high level of SARS-CoV-2 shedding in the upper respiratory tract, even among pre-symptomatic patients is responsible for the transmissibility of COVID-19 and entails the need for extreme caution to be taken by ophthalmologists while performing this previously seemingly innocuous examination.

Besides wearing adequate personal protective equipment (PPE), ophthalmologists also need to have a barrier between themselves and the patient so as to impede these airborne droplets. A number of barriers are being proposed presently which include a) Built-In acrylic breath shields and can also happen indirectly; when hands come in contact with contaminated surfaces and subsequently touch the face.

In this experimental study, 12 puffs of fine mist were sprayed over a period of 1 minute using “magenta-colored dye” and “cyan-colored dye” for analyzing proximal barrier and distal barrier respectively. To access the amount of contamination of the slit lamp, caused by sprayed “magenta” and “cyan” colored dye, we covered the entire slit lamp with appropriately sized white-colored cotton sheet. The stained sheets were individually photographed and then the images were first cropped, then color threshold adjusted and then converted to binary and finally fraction of surface area stained was calculated using the Imagej software. \( P_{\text{Surface Area}_{\text{magenta fraction}}} \) and \( P_{\text{Surface Area}_{\text{cyan fraction}}} \) during analysis of “proximal barrier” and “distal barrier”, where \( P \) refers to various parts of slit lamp.

Purpose: The aim of this study was to describe a poly-vinyl chloride air condition (PVC AC) curtain shield placed at the intervening space between the chin rest and the illuminating and optical arm of the slit lamp microscope (distal barrier) instead of the present position at the oculars (proximal barrier) to guard against severe acute respiratory syndrome Coronavirus 2. This experimental study was done to validate and compare the protection offered by the conventional breath shields and the one described by us in a simulated environment.

Methods: In this experimental study, 12 puffs of fine mist were sprayed over a period of 1 minute using “magenta-colored dye” and “cyan-colored dye” for analyzing proximal barrier and distal barrier respectively. To access the amount of contamination of the slit lamp, caused by sprayed “magenta” and “cyan” colored dye, we covered the entire slit lamp with appropriately sized white-colored cotton sheet. The stained sheets were individually photographed and then the images were first cropped, then color threshold adjusted and then converted to binary and finally fraction of surface area stained was calculated using the Imagej software. \( P_{\text{Surface Area}_{\text{magenta fraction}}} \) and \( P_{\text{Surface Area}_{\text{cyan fraction}}} \) during analysis of “proximal barrier” and “distal barrier”, where \( P \) refers to various parts of slit lamp.

Results: The entire surface area of the cloth covering the slit lamp was 9912.45 cm². The surface area of the cloth which was stained when using the “proximal barrier” was 567.50 cm² whereas when using the “distal barrier” was 222.93 cm². When using proximal barrier, 97.71% of the staining was present on the slit lamp base, viewing arm, illumination arm and the pivot of the slit lamp. While using the distal barrier shield no parts of the viewing arm, illumination arm, the pivot or the mechanical base with joystick were stained.

Conclusion: The novel PVC AC curtain shield provides better barrier against the simulated contaminated stream of patient’s breath directed towards the working parts of the slit lamp as compared to conventional slit lamp oculars mounted breath shields.

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add-on universal acrylic breath shields,[9] b) self-made or customized acrylic/X-Ray film breath shield shields[10] and c) a wide (210 × 297 mm) flexible polyvinyl chloride (PVC) plastic sheet breath shield.[11] We believe that the small size of these breath shields and their proximity to the ophthalmologist and not the patient may limit their “protective effect” in preventing the aerosols and droplets coming in contact with the examining ophthalmologist and those parts of the slit lamp that are frequently handled while examining patients. We propose shifting the location of the breath shield from its present position at the oculars (Proximal Barrier) to the intervening space between the chin area and the illuminating and optical arm (Distal Barrier) [Fig. 1] of the slit lamp microscope to provide greater protection to the slit lamp parts, table, ophthalmologist’s hands and torso from getting directly contaminated by the patient’s breath generated respiratory droplets. Hence, we undertook this experimental study to validate the protection offered by the conventional breath shields and the one described by us in a simulated environment.

Methods

Besides the financial constraints, India in a state of lockdown so as to mitigate the spread of COVID-19 there was a non-availability of resources[12,13] like 1) Digital high-vision, high-speed video and Laser system with vector analysis system,[14] 2) customized mannequins for simulating a patient and other an ophthalmologist seated across a slit lamp and 3) a tri-flow deep breathing lung exerciser or physiotherapy device along with a pump system to create an expiration system; hence we devised an alternative.

Enumeration of presently available breath shields (Proximal Barrier)

All the various breath shields being advocated presently represent “proximal barriers”, i.e., barriers in close proximity to the examining ophthalmologist. They have a flat plate-like design made of acrylic/PVC with holes at upper end to allow for fitting of the ocular eye pieces, having dimensions ranging from 4 inches by 5 inches8 to 7.5 inches by 8.5 inches9,10 to 7.5 inches by 11.5 inches. All these breath shields are inserted behind the viewing arm by dangling over the eye pieces8-10 or by hooking between the oculars and the magnification changer11 of the slit lamp, i.e. at the proximal end of the slit lamp or the end near to the examining ophthalmologist. [Fig. 1 inset].

Creation of new design (Distal Barrier)

We modified our slit lamp to insert a protective shield near the distal end of the slit lamp or the end farthest to the examining ophthalmologist, i.e. shield in close proximity to the patient’s face This was done in the following manner: a) Re-positioning of the supply cable to the slit lamp bulb: We removed the electric cable concealed within the hollow of the pipe skeleton of the chin rest and forehead tape assembly and exteriorized the connection between the halogen bulb and the power supply/rheostat of the slit lamp. This helped in creating a free space between the chin rest/forehead head assembly and the illuminating arm of the slit lamp. [Fig. 2a] b) Wooden blocks/Pedestals: The author, RM, cut 2 cubical wooden blocks of 8 inches1 each. The centre of the block was excavated partially nearly 1.5 inch in depth with help of a chisel. A hole was drilled through the center of the chiseled area. These wooden blocks were then fixed to the slit lamp table top alongside of the guide-rail tracks of slit lamp’s mechanical base in the intervening space between the chin rest/forehead assembly and the illuminating arm of the slit lamp with the help of screw passing through the hole within the chiseled area of the wooden blocks. These wooden blocks were meant act as pedestals [Fig. 2a].

c) Wooden frame: The author, RM, then fashioned 2 cylindrical wooden poles of a diameter which could easily fit within the gauged/chiseled area of the previously described wooden blocks/pedestals. In order to maintain the parallel space between the 2 wooden poles resting within the pedestals, the top end of these wooden poles were fixed with 2 flat rectangular wooden sticks, hence creating a “U-shaped” frame closed at its top end and open at its bottom end [Fig. 2b].

Figure 1: “Slit Lamp Base” [table top (TT), mechanical base (MB) joy stick (j)]; 2 “Viewing Arm” (VV, VH are vertical and horizontal parts of viewing arm respectively, oculars (o) plus magnification changer (M)); 3 “Illumination Arm” (light adjustment column (S), lamp housing (h)); 4 is junction of viewing and illumination arms or “pivot (p) and 5 is “Patient Positioning Arm” elevation knob (K), chin rest (C) and forehead tape (F). Downward arrow and inset (i) is akin to breath shields which are inserted behind the viewing arm upward blue-with inset (ii) represents novel concept of placement of breath shield.
First, after removing rail guards and lifting the mechanical base (on which the joystick of the slit lamp is attached) of the slit lamp from the underlying tabletop, a piece of white colored cloth was draped over the slit lamp table. Secondly, the entire illuminating arm of the slit lamp was draped in cotton cloth. And finally, the mechanical base along with the joystick and the visualizing arm of the slit lamp were covered with the white cotton cloth [Fig. 3a].

II. “Respiratory Droplet/Aerosol” like generation system [Fig. 3b]:

Analysis of proximal barrier: We used a 50 ml fine mist spray bottle of a hand sanitizer and after emptying it we filled it half with water and then added 2 ml of “magenta colored dye” (Epson Ink Bottle, 664, Magenta, Seiko Epson Corporation, Suwa, Nagano, Japan) retrieved from the refilling well of an ink-jet printer (Epson L365, Seiko Epson Corporation, Suwa, Nagano, Japan) available at the hospital premises. This magenta dye stained water filled mist spray bottle was put on the chin rest of the slit lamp making roughly an angle of 20 degree to the horizontal to simulate the expiration of air of the patient’s nares.

In order to ensure that no air was trapped within the pipe of the spray delivery system of the bottle the spray nozzle was depressed 2-3 times before docking it on the chin rest platform. Keeping in mind that it roughly takes a minute to have a rough screening of anterior segment on a slit lamp examination, we pressed the nozzle 12 times over a period of 1 minute (1 spray every 5 seconds). Sprays were divided into 4 batches of 3 sprays each according to the positions of illumination arm and viewing arm with respect to each other plus an extra spray was done at the end [Fig. 3b]:

1) First batch signifying diffuse/direct focal examination of the right eye: viewing arm and illuminating arm in parfocal position with illuminating arm swung to the left by 20-30 degree, with the slit lamp viewing arm directly opposite to the supposed right eye position.

2) Second batch signifying diffuse/direct focal examination of the left eye: viewing arm and illuminating arm in parfocal position with illuminating arm swung to the right by 20-30 degree, with the slit lamp viewing arm directly opposite to the supposed left eye position.

3) Third batch signifying retroillumination examination of the right eye: viewing arm and illuminating arm in a confocal position with the slit lamp viewing arm directly opposite to the supposed right eye position.
4) Fourth batch signifying retroillumination examination of the left eye: viewing arm and illuminating arm in a confocal position with the slit lamp viewing arm directly opposite to the supposed left eye position. To simulate the presence of a proximal acrylic breath shield we dangled a A4 sized paper sheet of GSM 100 over the slit lamp oculars. The size of the A4 sheet of paper is 8.27 inches * 11.69 inches and represents the size of the largest commercially available shield. [Fig. 3b, inset i].

Analysis of distal barrier: As previously described, this time filled the bottle half with water to which we added 2 ml of “cyan colored dye” (Epson Ink Bottle, 664, Magenta, Seiko Epson Corporation, Suwa, Nagano, Japan) retrieved from the refilling well of an ink-jet printer (Epson L365, Seiko Epson Corporation, Suwa, Nagano, Japan) available at the hospital premises. This cyan dye stained water filled mist spray bottle was put on the chin rest of the slit lamp and further steps were repeated as before. However, this time the PVC AC curtain sheet representing the “Distal Barrier” was put in place before initiating the spray. [Fig. 3c]

III. Photography of Equipment and Draped Cloth: At the end of the experiment the entire slit lamp and its immediate surrounding were photographed using a mobile phone camera. Thereafter the draped pieces of white cloth, now at places stained with “magenta colored dye”/“patient’s breath” were removed from the slit lamp and arranged [Fig. 4] on the tiled floor as follows:

- Part 1: Slit Lamp base (a: tabletop; b: mechanical base with joystick and c: distal edge of mechanical base)
- Part 2: Viewing arm (a: mechanical column and b: oculars plus magnification changer with its base/bracket),
- Part 3: Illumination arm (a: slit/light adjustment column and b: lamp housing),
- Part 4: Pivot (which represents the junction of viewing and illumination arms)
- Part 5: Patient positioning arm (which includes from below to above, as follows: a: ledge, b: patient grab bars with railing, c: chin rest elevation knob with railing, d: chin rest and e: forehead tape with railing)

IV. Image Analysis of the Stained Cloth [Fig. 5]: The images of white cloth stained with “magenta colored dye” or “cyan colored dye”, simulating patient’s breath generated aerosols in 2 different settings (using “proximal barrier” vs “distal barrier” respectively), obtained were analyzed using the ImageJ software (Java-based image processing program, National Institutes of Health (NIH), Bethesda, Maryland, USA and the Laboratory for Optical and Computational Instrumentation (LOCI), University of Wisconsin, Wisconsin, USA). For image analysis, the images were first cropped, color threshold adjusted and then converted to binary using the ImageJ software. Thereafter the measurements were done after setting the measurements to area fraction (P_{magenta stain} (%) during analysis of “proximal barrier” and P_{cyan stain} (%) during the analysis of “distal barrier”, where P refers to Parts 1-5 of the slit lamp).

V. Measurement of Total Area Stained/Area of the Slit Lamp Contaminated by Patient’s Breath: a) Calculation of the Entire Surface Area of Slit Lamp: All the pieces of white cloth used to cover the slit lamp were measured individually with the help of a measuring tape; this gave the actual measurement of each piece of cloth or the surface area of the particular part of the slit lamp (P_{surface total} (cm^2), where P refers to Parts 1-5 of the slit lamp). The total surface area of the slit lamp was then calculated as follows: Surface Area_{total} (cm^2) = P_1 Surface Area + P_2 Surface Area +… + P_5 Surface Area

b) Calculation of the “Magenta Stained” Surface Area of Slit Lamp/Area of the Slit Lamp Contaminated by Patient’s Breath (For Analyzing Proximal Barrier): From the P_{magenta stained} (%) obtained using measuring tape and P_{cyan stained} (%) obtained using ImageJ software, we were able to back calculate true amount of “magenta dye stained” surface area of the different parts of the slit lamp, as follows:

\[ P_{magenta stained} (cm^2) = \frac{P_{magenta stained} (%) \times P_{cyan stained} (cm^2) \times 100}{100} \]

\[ P_{cyan stained} (cm^2) = \frac{P_{cyan stained} (%) \times P_{magenta stained} (cm^2) \times 100}{100} \]

c) Calculation of the “Cyan Dye Stained” Surface Area of Slit Lamp/Area of the Slit Lamp Contaminated by Patient’s Breath (For Analyzing Distal Barrier): From the P_{cyan stained} (%) obtained using measuring tape and P_{magenta stained} (%) obtained using ImageJ software, we were able to back calculate true amount of “cyan dye stained” surface area of the different parts of the slit lamp, as follows:

\[ P_{cyan stained} (cm^2) = \frac{P_{cyan stained} (%) \times P_{magenta stained} (cm^2) \times 100}{100} \]

Results

The entire surface area of the slit lamp under study, Surface Area_{total} (cm^2), was 9912.45 cm². The surface area of the slit lamp presumably contaminated by patient’s breath (magenta dye stained), Surface Area_{magenta stained} (cm²), when using the “proximal barrier” was 567.50 cm² whereas the surface of the slit lamp presumably contaminated by patient’s breath (cyan dye stain), Surface Area_{cyan stained} (cm²), when using the distal barrier was 222.93 cm².

The fraction of area contaminated by the patient’s breath while using the proximal barrier (P_{magenta stained fraction}) and fraction of area contaminated by the patient’s breath while using the distal barrier (P_{cyan stained fraction}) are tabulated in Table 1. and the actual or measured surface areas of different parts of slit lamp (P_{surface area}) along with calculated surface area of magenta and cyan stained white cloth draping the slit lamp (P_{magenta stained} and P_{cyan stained}, respectively) are tabulated under Table 2.

Discussion

Our study demonstrated that the amount of contamination of the slit lamp during the examination of the patient by simulated breathing was more while using a barrier at the proximal end (the end near to an ophthalmologist) as compared to using a barrier at the distal end of the slit lamp (the end farthest to the examining ophthalmologist, i.e. barrier in close proximity to the patient’s end) (567.50 cm² vs 222.93 cm² respectively).
A sub-analysis for assessing the efficacy of the proximal breath shield showed that although none (Zero %) of the Part 5 (Patient Positioning Arm) was contaminated when examining a patient with a proximal barrier in place, there was 100% contamination of the working parts of the slit lamp; Part 1, 2, 3 and 4 (Slit lamp base, viewing arm, illumination arm and the pivot respectively). In addition more than 90% of surface area of the slit lamp contaminated by the patient’s breath was essentially those parts of the slit lamp with which the examining ophthalmologist is constantly in contact with (in order of their increasing frequency): a) table top of the slit lamp base (80.72 cm²), mechanical column of the viewing arm (84.15 cm²), the slit adjustment column of the illumination arm (156.61 cm²) and the mechanical base with joy stick (204.31 cm²) respectively. In addition, only 13.28 cm² of the proximal barrier (acrylic breath shield) was found to be contaminated which represented 2.29% of the entire contamination. Hence, 97.71% of the contaminations was subjected to Parts 1, 2, 3 and 4 (Slit lamp base, viewing arm, illumination arm and the pivot respectively) of the slit lamp.

The scatter pattern of contamination on the proximal barrier (acrylic breath shield) was primarily on the lower/inferior half of the barrier (triangular scatter pattern with the base down) (Fig. 6, hence establishing that the major onslaught of contaminating stream of breath was directed more inferiorly i.e. directed towards the hands, arms and torso of the ophthalmologist and not superiority towards the ophthalmologists’ face. A similar sub-analysis for assessing the efficacy of a distal breath shield (novel PVC AC sheet barrier) revealed that except for Part 1c (distal edge of the mechanical base of the slit lamp base, 13.36 cm²), the rest 94.01% of surface area of the slit lamp contaminated by the patient’s breath were essentially those parts of the slit lamp with which the examining ophthalmologist does not actively come in contact with while doing slit lamp examination. These parts in order of their increasing frequency were: a) ledge of the patient positioning arm (9.63 cm²), chin rest (48.01 cm²) and the table top of the slit lamp base (151.93 cm²) respectively. About 25.86% of contaminated surface area (57.64 cm²) of the slit lamp involved the Part 5 (Patient Positioning Arm) whereas out of the rest of 74.14% of the surface contaminated, more than 90.00% (91.92%) was represented by the distal part of the table top of the slit lamp base (Part 1a) whereas a mere 8.08% was the distal edge of mechanical base of the slit lamp base (Part 1c). Both these parts were adjacent to the Patient positioning arm of the slit lamp, directly under the lower end of the distal shield, receiving
the trickle of the cyan colored dye from above [Fig. 6]. None of the Parts 2, 3, 4 (Viewing arm, illumination arm and the pivot respectively) and Part 1b (mechanical base with joystick) were contaminated by the patient’s breath while using a distal breath shield (novel PVC AC sheet barrier), which was apparent by the absence of any cyan colored stain beyond the distal edge of mechanical base of the slit lamp base i.e. Part 1c [Fig. 6]. Both Parts 1a and 1c represent areas of the slit lamp not in the working domain of the examining ophthalmologist.

This shows that the distal barrier (novel PVC AC sheet barrier) proves to be an effective barrier against the major onslaught of contaminating stream of patient’s breath directed towards the working parts of the slit lamp and hence provides protection for hands, arms and torso of the ophthalmologist doing the slit lamp examination as compared to the proximal barrier (acrylic breath shields), which fail in their endeavor of protecting the working parts of slit lamp and hence hands, arms and torso of the ophthalmologist [Fig. 6].

So, a distally placed shield effectively closes out any significant contamination of those working parts of the slit lamp which are actively engaged by the examining ophthalmologist, hence breaking the chain of contamination.

Our study has a few limitations which cannot be overlooked. First of the droplets and aerosols generated from a mist spraying bottle may not be a true mimic of the aerosols generated by patient breathing. Second the dilution of the dye used in our study for visualizing the aerosols was on the basis of subjective

Table 1: The fraction of area contaminated by the patient’s breath while using the proximal barrier (\( P_n \) Surface Area \(_{magenta} \) fraction\(^{a} \)) and fraction of area contaminated by the patient’s breath while using the distal barrier (\( P_n \) Surface Area \(_{cyan} \) stained fraction\(^{a} \))

| Part No. | Part Name | Fraction of Surface Area Stained (%) |
|---------|-----------|--------------------------------------|
|         |           | Magenta Stained | Cyan Stained |
| 1       | Slit Lamp Base | 2.446 | 4.604 |
|         | a. Table Top |                  |              |
|         | b. Mechanical Base with Joystick | 19.721 | 0.000 |
|         | c. Distal Edge of Mechanical Base | 0.000 | 4.954 |
| 2       | Viewing Arm | 19.311 | 0.000 |
|         | a. Mechanical Column |                  |              |
|         | b. Oculars plus Magnification Changer | 3.526 | 0.000 |
| 3       | Illumination Arm (plus) | 11.667 | 0.000 |
|         | a. Slit Adjustment Column |                  |              |
|         | b. Halogen Lamp Housing | 0.000 | 0.000 |
| 4       | Pivot (The Viewing and Illumination Arm Junction) | 2.596 | 0.000 |
| 5       | Patient Positioning Arm | 0.000 | 3.932 |
|         | a. Ledge |                  |              |
|         | b. Chin Rest Elevation Knob with Railings | 0.000 | 0.000 |
|         | c. Patient Grab Bars | 0.000 | 0.000 |
|         | d. Chin Rest | 0.000 | 16.540 |
|         | e. Forehead Tape | 0.000 | 0.000 |

Figure 5: Percentage surface area contamination assessment using the ImageJ software. cropped image of cloth covering the table top part of the slit lamp (d); magenta and cyan stain represent area of contamination. Image (d) was color threshold adjusted (a), converted to binary (b) and measurements done after setting the measurements to “area fraction” and results (c) obtained [\( P_n \) Surface Area \(_{magenta} \) fraction\(^{a} \)]. (e-g) show assessment of percentage surface area contamination cyan colored dye expressed as [\( P_n \) Surface Area \(_{cyan} \) stained fraction\(^{a} \)].

Figure 6: [Image of Figure 6 showing the distal barrier's effectiveness against patient's breath contamination.]

\(^{a}\) The fraction of area contaminated by the patient’s breath while using the proximal barrier (\( P_n \) Surface Area \(_{magenta} \) fraction) and fraction of area contaminated by the patient’s breath while using the distal barrier (\( P_n \) Surface Area \(_{cyan} \) stained fraction)
Table 2: The actual or measured surface areas of different parts of slit lamp (P\textsubscript{n} Surface Area) along with calculated surface area of magenta and cyan stained white cloth draping the slit lamp (P\textsubscript{m} Surface Area magenta stained and P\textsubscript{c} Surface Area cyan stained respectively) are tabulated under Table 2.

| Part No. | Part Name | Surface Area (cm\textsuperscript{2}) | Surface Area Magenta Stained (cm\textsuperscript{2}) | Surface Area Cyan Stained (cm\textsuperscript{2}) |
|----------|-----------|--------------------------------------|------------------------------------------------------|---------------------------------------------------|
| 1        | Slit Lamp Base | a. Table Top 3300.00 | 80.72 | 151.93 |
|          |           | b. Mechanical Base with Joy Stick 1036.00 | 204.31 | 0.00 |
|          |           | c. Distal Edge of Mechanical Base 269.75 | 0.000 | 13.36 |
| 2        | Viewing Arm | a. Mechanical Column 435.75 | 84.15 | 0.00 |
|          |           | b. Oculars plus Magnification Changer 841.50 | 29.67 | 0.00 |
| 3        | Illumination Arm | a. Slit Adjustment Column 1342.29 | 156.61 | 0.00 |
|          |           | b. Halogen Lamp Housing 378.35 | 0.00 | 0.00 |
| 4        | Pivot (The Viewing and Illumination Arm Junction) | | 463.88 | 12.04 | 0.00 |
| 5        | Patient Positioning Arm | a. Ledge 245.00 | 0.00 | 9.63 |
|          |           | b. Patient Grab Bars with Rails 613.40 | 0.00 | 0.00 |
|          |           | c. Chin Rest Elevation Knob with Rails 186.00 | 0.00 | 0.00 |
|          |           | d. Chin Rest 290.25 | 0.00 | 48.01 |
|          |           | e. Forehead Tape with Rails 510.28 | 0.00 | 0.00 |
|          |           | **Total surface area (cm\textsuperscript{2})** 9912.45 | 567.50 | 222.93 |

Figure 6: “A” shows divide in contamination area using distal barrier (cyan stain) and proximal barrier (magenta stain). “B” shows stains limited to the chinrest (c) ledge of patient position part and anterior edge of the base of the slit lamp (a) due to trickle (t) of cyan dye across the PVC sheet. “C” shows minimal protection by proximal barrier depicted by magenta spots on inferior half of paper sheet (bounded by triangle) with contamination occurring on the slit lamp viewing arm (v), joy stick (j) slit lamp table top (*) and floor below oculars (as shown bounded by a rectangle) in “D” observation. Third the smaller droplets and aerosols which may have settled and colored the evaluation sheets may have been missed in the photograph due to the native ISO settings or camera’s sensor resolution. Inspite of these limitations the results of the study do point towards a greater level of safety in using a distally placed shield compared to a proximal shield. There is an unmet need of a study using instruments with higher objectivity as high magnification high speed cameras which can detect even smaller volumes of aerosol spread and contamination.

**Conclusion**

In ophthalmic settings despite symptom based triage, we need to be cautious and examine each and every patient as if he or she is an asymptomatic transmitter of SARS-CoV-2 and hence the need for maximum protection of the examining ophthalmologist as well as the ophthalmic equipment which can be better provided by changing the barrier from proximal to a much distal position on the slit lamp.

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**Conflicts of interest**

There are no conflicts of interest.

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