Development of a Device to Reduce Oropharyngeal Aerosol Transmission

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Abstract: The world-wide COVID-19 pandemic has greatly impacted dental practice. Issues confronting practicing dentists include possible transmission of disease by droplets/aerosol or contact with contaminated surfaces. Dentists are at increased risk due to their proximity to the oropharynx. In an effort to reduce potential exposure to aerosols generated during treatment, a device has been developed in which a polycarbonate shield is mounted to the dental operating microscope with an attached high velocity vacuum hose. Anemometer measurements demonstrate an exhaust outflow of 3.9 ft/min at a position approximating the patient’s oropharynx. More research may be warranted using this or similar approaches to mitigate aerosol transmission.
Development of a Device to Reduce Oropharyngeal Aerosol Transmission

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The author denies any conflicts of interest
Statement of Clinical Relevance

The COVID-19 pandemic has increased concerns about transmission virus in aerosols generated during dental procedures. As a method to reduce unimpeded aerosol transmission, a polycarbonate shield with an attached high speed vacuum line was mounted on the dental operating microscope.
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<tr>
<th>Description of Item</th>
<th>Company</th>
<th>Catalog / Part #</th>
<th>Purpose</th>
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<td>18x24x.093 clear Polycarbonate</td>
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<td>Shield</td>
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<td>AC Infinity</td>
<td>AI-CLS4</td>
<td>Fan</td>
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<tr>
<td>4 in. flexible ducting</td>
<td>AC Infinity</td>
<td>AI-DTA4</td>
<td>ducting</td>
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<tr>
<td>(2) 4 in. inlet flange</td>
<td>POWERTEC</td>
<td>POWERTEC 70126</td>
<td>used to attach ducting to shield, 2nd flange cut in half to create directional edge</td>
</tr>
<tr>
<td>Air carbon filter</td>
<td>AC Infinity</td>
<td>AC-DCF4</td>
<td>air filter</td>
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<tr>
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<td>49-56-9646</td>
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<tr>
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<tr>
<td>#10-32 x 1/2 in. Flat head screw</td>
<td>Everbilt</td>
<td>803971</td>
<td>Hold inlet flange to shield</td>
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</table>
Abstract

The world-wide COVID-19 pandemic has greatly impacted dental practice. Issues confronting practicing dentists include possible transmission of disease by droplets/aerosol or contact with contaminated surfaces. Dentists are at increased risk due to their proximity to the oropharynx. In an effort to reduce potential exposure to aerosols generated during treatment, a device has been developed in which a polycarbonate shield is mounted to the dental operating microscope with an attached high velocity vacuum hose. Anemometer measurements demonstrate an exhaust outflow of 3.9 ft/min at a position approximating the patient’s oropharynx. More research may be warranted using this or similar approaches to mitigate aerosol transmission.

Key Words
COVID-19, endodontics, aerosol, dental operating microscope
Introduction
The global COVID-19 pandemic, due to an exponential increase in SARS-CoV-2 infections [1], has had a major impact on health care delivery [2, 3]. As of April 2020, the Center for Disease Control and Prevention (CDC) [4] and the American Dental Association [5] issued guidance to postpone all but emergency and urgent dental conditions. The rationale is to prevent disease transmission and to conserve personal protective equipment (PPE).

The transmission of the SARS-CoV-2 virus is believed to primarily be via droplets/aerosol originating from the oropharynx or by contact with surfaces contaminated with the virus [2, 6, 7]. The CDC recommends that aerosol generating procedures performed on known or suspected COVID-19 patients should be in negative pressure/airborne infection isolation rooms (AIIRs) [8]. However, an important additional clinical concern is how to deliver aerosol generating procedures to patients who are infected, but asymptomatic. The onset for COVID-19 infection is up to 14 days and about 80% of patients may be either asymptomatic or have symptoms reminiscent of mild flu or seasonal allergies [9]. Moreover, the growing recognition of nosocomial transmission via aerosol generation has prompted a re-examination of aerosol production in the dental operatory [10].

Given the lack of available negative pressure/AIIRs for dental treatment and the need to deliver endodontic treatment for patients who may or not be infected, there is a need to develop an engineering solution to mitigate aerosol exposure in the dental operatory. Here, is the description of a polycarbonate shield mounted to the dental operating microscope (DOM) with an attached high velocity vacuum hose. A description of its construction and measurement of evacuated airflow is provided.

Materials and Methods
The materials used in the construction of this device are listed in Table 1. Fig 1 and 2 illustrates the DOM-shield device and its use during endodontic treatment.

**Shield:** Both polycarbonate (Lexan™) and acrylic (Plexiglass™) have advantages and disadvantages in this application. The benefit of Plexiglass™ is that it is more transparent, less inclined to chemical discoloration and tends to be more scratch-resistant, but it does not have the same strength as polycarbonate. Polycarbonate has a higher impact resistance, allowing drilling without cracking.

An 18X24 rectangular 0.093” thick sheet of clear polycarbonate (Part 1PC1824A; Home Depot) was cut into an 18” diameter disk using a band saw. Next, a template was created by first removing the objective housing from the Global 6A microscope body (Fig 2A, M1028G 300, Global Surgical Co., St Louis, MO). Then, cardboard was affixed to the base the microscope and an outline was drawn. The polycarbonate disk was placed over the template. Using a Milwaukee Hole Dozer Bi-Metal Hole Saw (Milwaukee Tool, Brookfield, WI), a 2.5” hole was drilled through the polycarbonate to allow the DOM objective lens to hold the polycarbonate to the microscope body (Fig 2A, B). A 4-1/8” hole was drilled just posterior to the LED light housing to permit attachment of the exhaust hose (Fig 1C, 1D, 2B). Four additional 1/8 inch holes were drilled to attach the 4” inlet flange to the polycarbonate shield (Fig 1C, Part 70126, Powertec Inc, Waukegan, IL). A second inlet flange was cut in half and attached under the shield to help direct air flow (Fig 1C).

**Installation:**
Shield: After removing the locking ring from the objective lens, the threads of the objective lens were placed into the 2 ½ inch hole in the polycarbonate shield (Fig 2A). The locking ring was then reattached to the objective lens. The shield and objective lens were then threaded onto the body of the microscope. Note: the DOM positioning handles need to be placed in an upward direction (Fig 1A, B, C).

Ventilation and fan installation: Two ceiling tiles were removed. Using the same Milwaukee Hole Dozer 4 1/8" Hole Saw, a hole was placed in the ceiling tile and in the ceiling gypsum board (Sheetrock™) to gain access to the attic. After testing other fans, the AC Infinity Cloudline S4™ inline duct fan (AC Infinity Inc, City of Industry, CA) was selected as producing the least amount of vibration on the microscope. The AC Infinity Cloudline S4 inline duct fan features an 8-speed manual controller and plugs into a 110V outlet. The fan has dual ball bearings and very little vibration was noted when using the DOM. The AC Infinity Flexible 4-inch aluminum ducting (Part A1-DTA4, AC Infinity Inc, City of Industry, CA) was cut to length and attached to the Powertec 4-inch inlet flange (Part 70126, Powertec Inc, Waukegan, IL) on the polycarbonate disk with a 4-inch metal worm gear clamp (supplied with aluminum ducting) (Fig 1C). A 2nd inlet flange was cut in half and placed under the shield to help direct the intake air flow (Fig 1C). The inlet flange (Powertec) and a cut inlet flange was attached to the shield with four #10 machine screws.

The other end of the flexible ducting was attached to the intake end of the duct fan (Fig 1E, F). The ducting was attached to the microscope-mounting pole with two 24-inch cable ties (Fig 1E, F). The excess flexible ducting was placed on the exhaust end of the
duct fan and placed through the drop ceiling, gypsum board, attic and out the roof. An AC Infinity carbon filter (Part AC-DCF4, AC Infinity Inc, City of Industry, CA) was used at the terminus. A suitable HEPA filter was not available due to current government COVID-19 restrictions.

The acrylic shield and hosing can be disinfected with 0.5% NaOCl. Prior studies have demonstrated that a 1 min exposure of either 0.1% or 0.5% NaOCl is effective in reducing coronavirus levels ~1,000-fold on a stainless steel surface with serum as an additional contaminant [11].

The velocity of the exhaust system was determined by placing a handheld hot-wire anemometer (TES-1340, TES Electrical Electronic Corp., Taipei, Taiwan) directly under the vacuum inlet and 10" beneath the DOM objective lens (to approximate the location of the patient’s oropharynx). The TES-1340 has a dynamic airflow range with a stated accuracy of ± 3%. Airflow was measured over a 1 min period with recording of mean airflow.

**Results**

To date, patients have accepted the use of this exhaust device as contributing to both their safety as well as the dentist and staff. While noticeable, the sound of the exhaust is not disturbing. The results of the anemometer indicated that the mean exhaust airflow is 498 ft/min at the vacuum hose inlet. At the DOM objective lens, the mean airflow was 163 ft/min at 2.5" below the lens, 59 ft/min at 5" below the lens and 3.9 ft/min at 10" below the lens (10" is approximately at the patient’s oropharynx).
Discussion

The CDC has issued guidelines that confirmed or suspected COVID-19 patients be treated in AIIR facilities. Yet a much broader range of patients who require endodontic treatment may be either uninfected or infected and asymptomatic. To address this larger population, a device was developed with the potential to reduce oropharyngeal aerosol transmission. Measurements of airflow indicate that this device generated an exhaust airflow of about 3.9 ft/min at the approximate location of the patient’s airway. The use of this device may mitigate aerosol transmission, serves as a sneeze guard, is accepted by patients, does not interfere with the delivery of endodontic treatment and is relatively inexpensive. Moreover, mitigation in aerosol transmission may have many benefits in reducing exposure to other airborne pathogens to the dentist and staff.

However, there are limitations to this device. First, it does not replace the AIIR recommended by the CDC for treating COVID-19 confirmed or suspected patients. Second, the demonstration of substantial exhaust airflow from the region of the oropharynx is consistent, but not sufficient to establish a significant reduction in aerosol transmission. This latter point should be evaluated in future research in a proper research environment [12]. However, this device, coupled with appropriate PPE may offer benefits in delivery of endodontic treatment.
Figure Legends.

Fig 1. A. Set-up of the evacuation system using a mock patient. B. View of the dental operating microscope (DOM) shield system from the dental assistant’s perspective. C. Close-up of the 18” round polycarbonate shield attached to the objective lens of the microscope. Note the exhaust hose has a flange on the bottom of the shield and on the side opposite of the DOM to facilitate collecting exhaust flow from the microscope side of the shield. D. View of the polycarbonate shield from the patient’s perspective. E. Side view. Illustrating the position of the exhaust hose on the DOM arms. F. Location of exhaust fan/blower/filter.

Fig 2. A. Schematic illustration of the attachment of the round polycarbonate shield to the DOM. B. An 18” diameter round polycarbonate shield with location of holes for DOM objective lens and attachment of exhaust hose.

References


Reviewer #1: This is a case report centered on the construction of a novel barrier device to protect the operator from treatment generated aerosol. The authors note that this is particularly important in the present COVID-19 pandemic. They describe the construction of the microscope-fitted device made of polycarbonate with a high velocity vacuum hose. The article is timely, well written (one misspelling of "installation" under materials and methods), with a clear description of the device. One concern for the device that was not mentioned is the concern that installing a device directly to a microscope may void the scope manufacturer's warranty. Otherwise I think our readers will find this timely and helpful as we all struggle to meet the safety demands of our patients during this pandemic.

I am unaware that this would void any scope manufacturer's warranty. I have had email conversations with Global surgical regarding this and no reply has indicated any concerns with any warranty. However, I never asked. I attached the ventilation fan with zip ties, No permanent alterations were done to the scope, arm or mounting pole.

Reviewer #2: Dear author(s) thank you for submitting the article entitled: "Development of a Device to Reduce Oropharyngeal Aerosol Transmission" reporting the manufacturing of a new exhaust system device that could benefit so many in the specialty.

I found the article suitable for publication pending only few considerations:

1) Instillation, should read installation

2) please describe the electrical and space demands (requirements) of the electric fan in the attic

I plugged it into the standard 110v 20 amp outlet receptacle, same outlet that I use for the microscope. The vent hose is 4 inches, space demand is very minimal.

<p>| Voltage       | 100-240V AC |</p>
<table>
<thead>
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<th>Frequency</th>
<th>50/60Hz</th>
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<tbody>
<tr>
<td>Max Power Draw</td>
<td>28 W</td>
</tr>
<tr>
<td>Average Power Usage</td>
<td>21 W</td>
</tr>
<tr>
<td>Current</td>
<td>1.2 A</td>
</tr>
<tr>
<td>Power Connector Type</td>
<td>US Plug (NEMA 1-15 Type-A)</td>
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</tbody>
</table>

3) Is there a need to disinfect the hoses leading up to the fan?

*We find spraying lysol in the intake for 15 seconds with the fan on is sufficient between patients. You may have a more scientific method.*

4) Can particulates truly be evacuated with the air flow? Any evidence or what is required for reduction of aerosols? Environmental tests with fluorescent particulates could be performed as well.

*Currently there is no scientific evidence to produce reduction of aerosols. I personally am very concerned with chairside treatment aerosol removal systems. Having the outtake exhaust within the treatment room may create unwanted shifts in air flow within the treatment room. Example would be The PAX2000 Extraoral Dental Suction System.*

5) What is the noise generated by the airflow at the level of patients ears? Do they need earplugs? Have you measured it?

*Absolutely not. The level of noise is very similar to a white noise sound machine. My patients find it very comforting and relaxing.*
<table>
<thead>
<tr>
<th>Total Airflow</th>
<th>205 CFM</th>
</tr>
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<tbody>
<tr>
<td>Total Noise</td>
<td>28 dBA</td>
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