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Development of a Device to Reduce Oropharyngeal Aerosol Transmission

ABSTRACT

The worldwide coronavirus disease 2019 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 because of 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 show 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. (J Endod 2020;46:1144–1148.)

KEY WORDS

Aerosol; COVID-19; dental operating microscope; endodontics

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MATERIALS AND METHODS

The materials used in the construction of this device are listed in Table 1. Figures 1 and 2 illustrate 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 18 × 24 rectangular 0.093-inch thick sheet of clear polycarbonate (Part 1PC1824A; Home Depot, Atlanta, GA) was cut into an 18-inch diameter disk using a band saw. Next, a template was created by first removing the objective housing from the Global 6A microscope body (M1028G 300; Global Surgical Co, St Louis, MO) (Fig. 2A). Then, cardboard was affixed to the base of 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-inch hole was drilled through the polycarbonate to allow the DOM objective lens to hold the polycarbonate to the microscope body (Fig. 2A and B). A 4 1/8-inch hole was drilled just posterior to the LED light housing to permit attachment of the exhaust hose (Figs. 1C and D and 2B). Four additional 1/8-inch holes were drilled to attach the 4-inch inlet flange to the polycarbonate shield (Part 70126; Powertec Inc, Waukegan, IL) (Fig. 1C). A second inlet flange was cut in half and attached under the shield to help direct airflow (Fig. 1C).

Installation Shield

After removing the locking ring from the objective lens, the threads of the objective lens were placed into the 2 1/2-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. It is important to note that the DOM positioning handles need to be placed in an upward direction (Fig. 1A–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 [Home Depot, Atlanta, GA]) to gain access to the attic. After testing other fans, the AC Infinity Cloudline S4 in-line 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 in-line duct fan features an 8-speed manual controller and plugs into a 110-V 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) was cut to length and attached to the Powertec 4-inch inlet flange (Part 70126, Powertec Inc) on the polycarbonate disk with a 4-inch metal worm gear clamp (supplied with aluminum ducting) (Fig. 1C). A second inlet flange was cut in half and placed under the shield to help direct the intake airflow (Fig. 1C). The inlet flange (Powertec) and a cut inlet flange were attached to the shield with 4 #10 machine screws.

The other end of the flexible ducting was attached to the intake end of the duct fan (Fig. 1E and F). The ducting was attached to the microscope-mounting pole with two 24-inch cable ties (Fig. 1E and 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) was used at the terminus. A suitable HEPA filter was not available because of current government COVID-19 restrictions.

The acrylic shield and hosing can be disinfected with 0.5% sodium hypochlorite. Prior studies have shown that a 1-minute exposure of either 0.1% or 0.5% sodium hypochlorite is effective in reducing coronavirus levels about 1000-fold on a stainless steel surface with serum as an additional contaminant. 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 inches 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-minute period with recording of the 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. Although 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 inches below the lens, 59 ft/min at 5 inches below the lens, and 3.9 ft/min at 10 inches 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

| Description of item | Company | Catalog/part no. | Purpose |
|---------------------|---------|-----------------|---------|
| 18 × 24 × .093 clear polycarbonate | Home Depot | 1PC1824A | Shield |
| 4-inch in-line duct fan | AC Infinity | AI-CLS4 | Fan |
| 4-inch flexible ducting | AC Infinity | AI-DTA4 | Ducting |
| Two 4-inch inlet flange | POWERTEC | POWERTEC 70126 | Used to attach ducting to the shield |
| Air carbon filter | AC Infinity | AC-DCF4 | Second flange cut in half to create directional edge |
| 2 1/2-inch Hole Dozer saw | Milwaukee | 59-56-9631 | Air filter |
| 4 1/8-inch Hole Dozer saw | Milwaukee | 49-56-9646 | To cut the hole for objective lens |
| 24-inch Cable Tie | Commercial Electric | GT-630HD | To cut the hole for the vent ducting |
| #10-32 × 1/2 inch flat-head screw | Everbilt | 803971 | Used to support ducting and fan |

TABLE 1 - A Description of the Parts Used in Construction
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\(^2\). However, this device coupled with appropriate personal protective equipment may offer benefits in the delivery of endodontic treatment.

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The author denies any conflicts of interest related to this study.
FIGURE 2 – (A) A schematic illustration of the attachment of the round polycarbonate shield to the DOM. (B) An 18-inch diameter round polycarbonate shield with holes for the DOM objective lens and attachment of the exhaust hose.

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