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COMPARATIVE EVALUATION OF AEROSOL MITIGATION DEVICES EMPLOYED AT A MILITARY DENTAL TREATMENT FACILITY

by

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Lieutenant Commander, Dental Corps
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A thesis submitted to the Faculty of the
Comprehensive Dentistry Graduate Program
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DEDICATION

To my son, Harrison Van Michael and daughter, Norah Evelyn Foster

DISCLAIMER

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ABSTRACT

Comparative Evaluation of Aerosol Mitigation Devices Employed at a Military Dental Treatment Facility

Dustin Aldridge Bond, DMD, 2022

Thesis directed by: Nicholas Hamlin, PhD, DDS, MS
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Introduction: Routine dental procedures utilize aerosol generating instruments (i.e., handpiece, ultrasonic scaler, air/water syringe) that potentially increase the risk for transmission of respiratory diseases. Recent global outbreaks of respiratory diseases such as severe acute respiratory syndrome associated coronavirus (SARS-CoV) and coronavirus disease 2019 (SARS-CoV-2, COVID-19) bring to the forefront the necessity for standard dental precautions to include protection from airborne droplets. The Naval Medical Leader and Professional Development Command (NML&PDC) Naval Postgraduate Dental School (NPDS) Comprehensive Dentistry Department implemented the use of the Jade Air Purification System and the PAX 2000X to reduce dental procedure produced aerosols.

Aims: The purpose of the study is to investigate the efficacy of the aerosol mitigation devices deployed at NPDS in response to the COVID-19 pandemic.

Methods: Aerosol-generating dental procedures were simulated on a dental manikin with citric acid (10%) added to the filtered water lines and utilizing universal indicating paper (UIP) placed strategically around the operatory, on the provider, and on the assistant to quantify the amount and spread of aerosol within the dental operatory. To determine effectiveness of the aerosol-mitigation devices, a baseline was established by collecting contaminated UIP after each of five simulated procedures performed with only the standard high-volume suction and saliva ejector aerosol-mitigating devices (Control group). Three additional conditions to be evaluated were; with the addition of the Jade Air Purifier (Test group #1), addition of the PAX 2000X (Test group #2), and finally with the addition of both the Jade Air Purifier and PAX 2000X used in combination (Test group #3). UIP were to be collected, inspected, scanned, and analyzed for color change related to settling of splatter containing citric acid.

Results: Five iterations of our control group were run for a total of 25 minutes of tooth preparation utilizing a total of 210 UIP test strips. No visible contamination was noted on any of the UIP strips. Based on our control group findings, testing with additional mitigation devices was deemed not beneficial. Therefore test groups #2, #3, and #4 were not conducted.

Conclusions: Under the simulated conditions tested, no detectable aerosol was observed when utilizing standard mitigation strategies to include rubber dam isolation, high-volume suction and saliva ejector. Additional in-vitro/in-vivo studies examining various conditional and environmental parameters are needed to support clinical recommendations.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATONS

ACH	Air Changes Per Hour
ADA	American Dental Association
AGP	Aerosol Generating Procedure
CDC	Centers for Disease Control
Co.	Company
COVID-19	Coronavirus Disease 2019
Dpi	Dots Per Inch
EOS	Extraoral Scavenger
etc.	Et Cetera
ft^2	square feet
ft^3	cubic feet
g	grams
HBV	Hepatitis B Virus
HCV	Hepatitis C Virus
HPCON	Health Protection Condition
HEPA	High Efficiency Particulate Air
HIV	Human Immunodeficiency Virus
HVE	High-Volume Ejector
i.e.	id est, “that is”
Ltd.	Limited Liability
M	Molarity

ml	Milliliter
N-95	Non-Oil-95 percent efficiency
NML&PDC	Naval Medical Leader and Professional Development Command
NPDS	Naval Postgraduate Dental School
PAX	Pure-Air-Xchange
pH	Potential of Hydrogen
PPE	Personal Protective Equipment
RPM	Revolutions Per Minute
SARS	Severe Acute Respiratory Syndrome
SARS-CoV	Severe Acute Respiratory Syndrome Associated Coronavirus
SE	Saliva Ejector
TiO_2	Titanium Dioxide
UIP	Universal Indicating Paper
US	United States
UV	Ultraviolet
W	Watt
WHO	World Health Organization
µm	Micrometer
“	Inches
%	Percent sign
<	Less-than sign

CHAPTER 1: Introduction

AEROSOLS IN DENTISTRY

According to a 2015 article published in the World Economic Forum in collaboration with Business Insider, "Dentist" is listed as the unhealthiest job in America with the most potential to damage the dentist's health. The authors used data from the US Department of Labor's Occupational Information Network to compare health risks from 974 occupations. "Dentist" scored high in the following three health risk categories to take the top spot: exposure to contaminants, exposure to disease and infections, and time spent sitting. [1] Dentists must do everything possible to protect themselves, their patients, and staff in order to reduce these potentially unhealthy and dangerous workplace hazards.

Since 1996, safe dental practice has relied on standard precautions. That year the Centers for Disease Control (CDC) expanded previous recommendations for guidelines for infection control in dental health care settings, known as universal precautions. [2] Standard precautions involve the use of personal protective equipment (PPE) for each patient regardless of symptoms or reported illnesses. PPE includes eye protection, face mask, gloves and gowns to prevent the transition of bloodborne pathogens, specifically Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), and Human Immunodeficiency Virus (HIV).

Recent global outbreaks of respiratory diseases such as severe acute respiratory syndrome associated coronavirus (SARS-CoV) and coronavirus disease (COVID-19) may again change standard dental precautions to include protection from airborne droplets. Routine dental procedures utilize aerosol generating instruments (i.e., handpiece, ultrasonic scaler, air/water syringe) and increase the risk for transmission of such respiratory diseases. An aerosol has been defined as a droplet <50µm in diameter. Aerosols can remain suspended in the air for long periods of time and can travel great distances. [3]

The World Health Organization (WHO) defines aerosol producing procedures as:

> **<u>Definition of aerosol generating procedures (AGPs) in oral health care:</u>**
>
> All clinical procedures that use spray-generating equipment such as three-way air/water spray, dental cleaning with ultrasonic scaler and polishing; periodontal treatment with ultrasonic scaler; any kind of dental preparation with high or low-speed hand-pieces; direct and indirect restoration and polishing; definitive cementation of crown or bridge; mechanical endodontic treatment; surgical tooth extraction and implant placement. [4]

CAUSE FOR CONCERN

A global outbreak of SARS occurred in 2003, infecting 8,098 people in 29 territories and killing 774 people. [5] The flu-like virus was transmitted via respiratory droplets and prompted the publication of several studies related to the spread of aerosols during dental procedures.

No new cases of SARS have been reported since 2004 and the disease is considered eradicated in humans. [6] COVID-19 on the other hand was first recognized in December 2019 and cases continue to be reported to this day. As of June 2022, according to the Centers for Disease Control and Prevention (CDC) over 85.9 million cases and 1 million deaths have been reported in the United States alone. [7]

COVID-19 dramatically changed the practice of dentistry. On March 16, 2020 shortly after the initial outbreak the American Dental Association (ADA) released recommendations that dental providers see patients for urgent or emergency dental care only. [8] Military installations elevated Health Protection Condition (HPCON) Levels to "Charlie" indicating substantial sustained community transmission. PPE recommendations for urgent/emergent dental procedures upgraded from standard precautions to include N-95 respirator masks, disposable gowns, head and shoe covers, and face shields. Additionally, aerosol reduction measures have been put into place to include utilization of negative pressure operatories, high volume suction, air scrubber devices, and air purifiers. The aerosol mitigation strategy implemented at Naval Medical Leader and Professional Development Command (NML&PDC) Naval Postgraduate Dental School (NPDS) in addition to pre-COVID-19 standards was the combined use of the Jade Air Purification System and the PAX 2000X high volume suction unit.

The use of the Sterisil water filtration system ensures that clean water enters our operatories before becoming aerosolized. The Sterisil System G4 produces distilled quality water utilizing a multi-stage process in which the water is purified through reverse osmosis, deionization, class A UV light, and a patented silver-based treatment. [9]

MITIGATION

The Jade Air Purification System (SCA5000C, Surgically Clean Air, Toronto, Ontario, Canada) reduces aerosols via a six stage process to filter, purify, and re-energize the air at a maximum air change rate of 406 cubic feet/minute (six air changes per hour:

2,000 cubic foot space). The first two stages capture large and small particles through a "Pre-Filter" and "HEPA-RX Filter" (99.2% of ultrafine particles 0.0025 microns in size and 99.998% of particles of 0.1 microns in size). The Jade then "deactivates" the air using an activated carbon filter, germicidal UV-C+ light and a titanium dioxide (TiO_2) catalyst. Finally the filtered, deactivated air is revitalized with negative ions as it passes through the revitalizing negative ion chamber. The introduction of negative ions can attract both airborne and surface positively charged particles, the resulting bonded particles are larger and heavier and therefore easier to be cleaned from the air. With this introduction of negative ions the Jade purification system is by definition an air scrubber. [10]

COVID-19 has a positively charged polybasic cleavage site located close to the binding site on the spike protein. This positively charged binding site allows strong bonding between the virus protein and the negatively charged human-cell receptors. [11]

The PAX 2000X high volume suction unit (KN99, Foshan Cicada Dental Instrument Co., Ltd. Guangdong, China) captures aerosols close to the source and utilizes a multi-stage filtration system at a maximum rate of 247 cubic feet per minute. Powered by a 1600w motor the unit pulls air through a 3.875" suction hood and down a flexible rotating arm. The air first passes through a primary fine filter capturing larger particles, then dual UV-C light is used to disinfect the air before it finally passes through an H14 HEPA filter. H14 HEPA filters are able to capture 99.995% of particles down to 0.1 microns. The PAX 2000X is designed to filter and purify the air and is therefore by definition an air purifier. [12]

OBJECTIVE OF THE STUDY

The purpose of this research was to evaluate the effectiveness of Jade Air Purification System and the PAX 2000X high volume suction unit, alone and in combination with the goal of providing a safe working environment for our providers, patients and staff.

CHAPTER 2: Materials and Methods

Study Design

This in vitro study was conducted within the Comprehensive Dentistry Department at NPDS, NML&PDC, Bethesda, Maryland. The purpose of the study was to investigate the efficacy of the aerosol mitigation devices deployed at NPDS in response to the COVID-19 pandemic. The selected operatory (Comprehensive Dentistry Department, Room: 2503) measures 15-feet 11-inches wide by 13-feet four-inches long (212.2 ft^2) by eight-feet high (1697.8 ft^3) with a closable door at the head of the patient. (Figure #1).

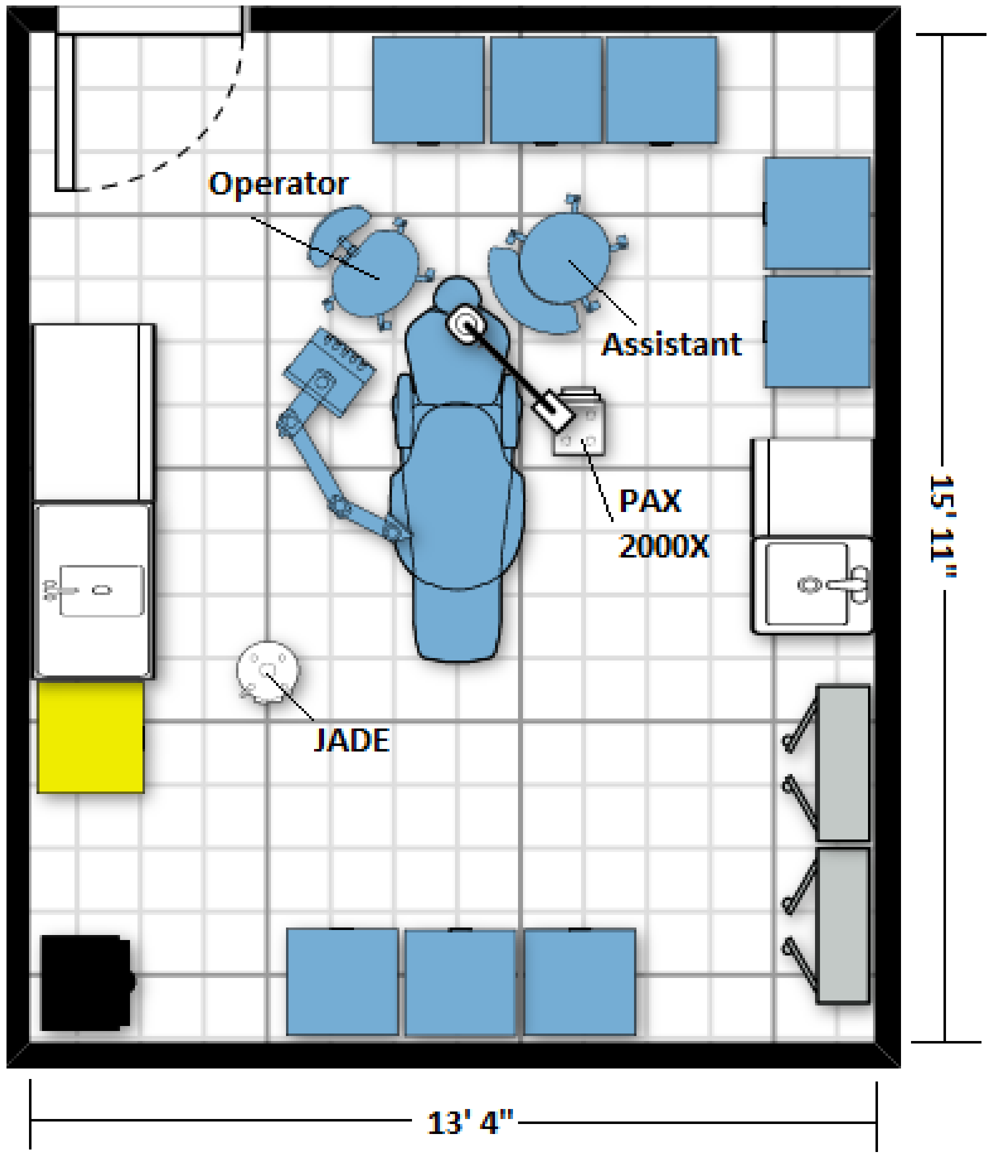
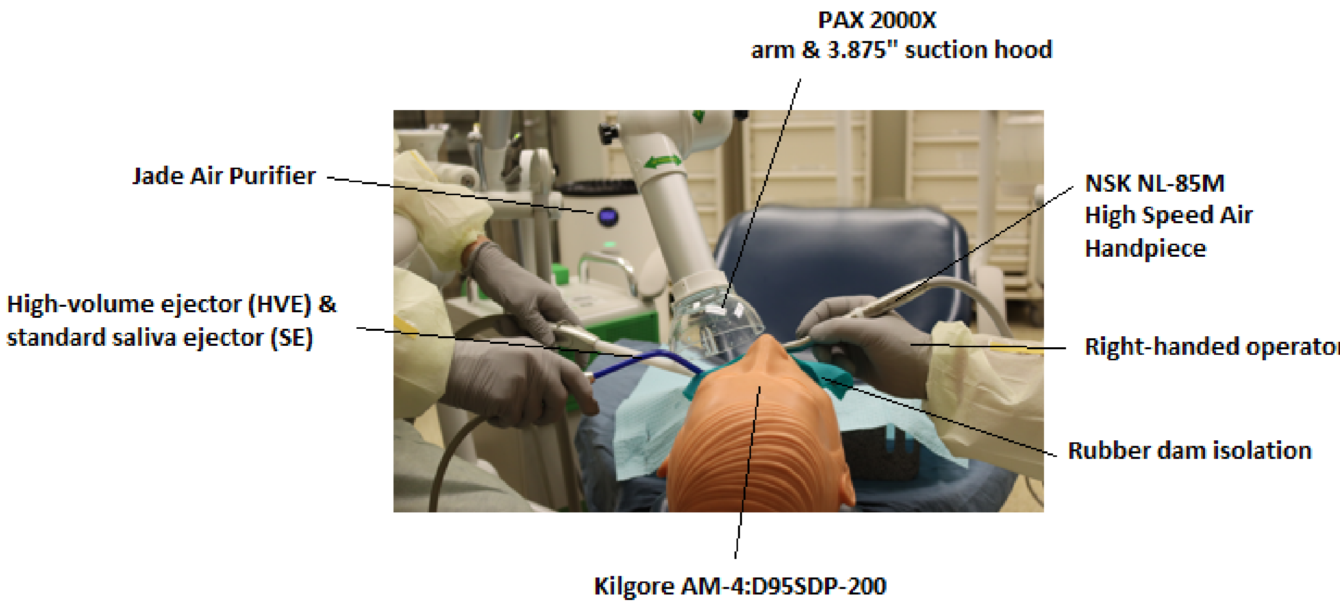


Figure 1. Floorplan Comprehensive Dentistry Department, Room: 2503. Diagrammatic representation of the closed door operatory including floor plan dimensions, positions of the operator, assistant, PAX 2000X, and Jade Air Purifier. Created using 2020 Icovia Room Planner (https://henryschein.icovia.com/)[13]

Aerosol-generating procedure simulation was achieved utilizing a dental manikin (Kilgore International, Inc. AM-4: D95SDP-200 a 32-tooth typodont with soft pink gingivae with screw-retained teeth, OCC-W-Oral Cavity Cover, Rubber mask, FRP Adult head with buccal plates) mounted using the CBM-3A-Bench and Chair Mount. The manikin was mounted on an A-dec 511 Dental Chair (A-dec 332 Delivery System, A-dec 551 Assistant's instrumentation, A-dec 6300 Dental light) which utilizes a two-liter self-contained water system. 104g of Citric acid Monohydrate ACS Reagent (Sigma Chemical Co. St. Louis, MO) was added to 937ml of filtered water (Sterisil water filtration system (Sterisil System G4)) to create a 1000ml solution (10% desired concentration) which was added the two-liter bottle. Procedure length for each iteration was standardized/timed five minutes, water used for each iteration was be measured and recorded.

Each experimental iteration was performed by a right-handed operator, simulating the preparation of typodont tooth #19 for a full contour crown under rubber dam isolation (#18 clamped with 56 Molar Winged Clamp) including teeth #18, #19, and #20. Each preparation began with a new typodont tooth and was performed utilizing an air turbine (NSK NL-85M High Speed) handpiece equipped with a single use Neodiamond 0816.8M medium grit modified flat end tapered diamond bur (Microcopy, Kennesaw, GA). The air turbine has a max speed of 444,000 rpm and disperses water coolant. The coolant (water) dispersion rate can be adjusted to the provider's desired handpiece coolant atomization. The air turbine was run at full speed and the coolant setting was set for maximum dispersion for the five minute duration of each test iteration. Water dispersion rate was measured at 88ml/min or 440ml per five minute test iteration. A dental assistant held the high-volume ejector (HVE) (5/16" internal opening) and saliva ejector in the area of the preparation for each iteration (Figure 2).



Photos courtesy of Dr. Ross, James M

Figure 2. Testing Setup. Illustration from the perspective of the provider, pictured on the right side. The dental assistant holding the high-volume ejector (HVE) and the PAX 2000X suction hood are seen pictured on the left

The provider and assistant wore personal protective equipment (PPE) to include: Nitrile gloves, N-95 respirator masks, eye protection (provider: dental loupes, assistant: safety googles), disposable gowns, head and shoe covers, and face shields (Dental Flex Face Shield).

In addition to the standard high-volume ejector and saliva ejector, the two aerosol mitigation devices of interest were the Jade Air Purifier (JADE: SCA5000C, Surgically Clean Air, Toronto, Ontario, Canada), a six stage extraoral scavenger filtration device, and the PAX 2000X extraoral dental suction unit system (KN99, Foshan Cicada Dental Instrument Co., Ltd. Guangdong, China). The Jade fan speed was to be set to "turbo" and the PAX power setting was to be fixed to 10, the highest setting for each respectively. To measure the propagation of aerosols dispersed during each test round, 42 universal indicator paper (UIP) (Ahlstrom-Munksjö, Helsinki, Finland) were placed throughout the operatory (30) (Figure 3), on the provider (six), and on the assistant (six) (Figure 4).

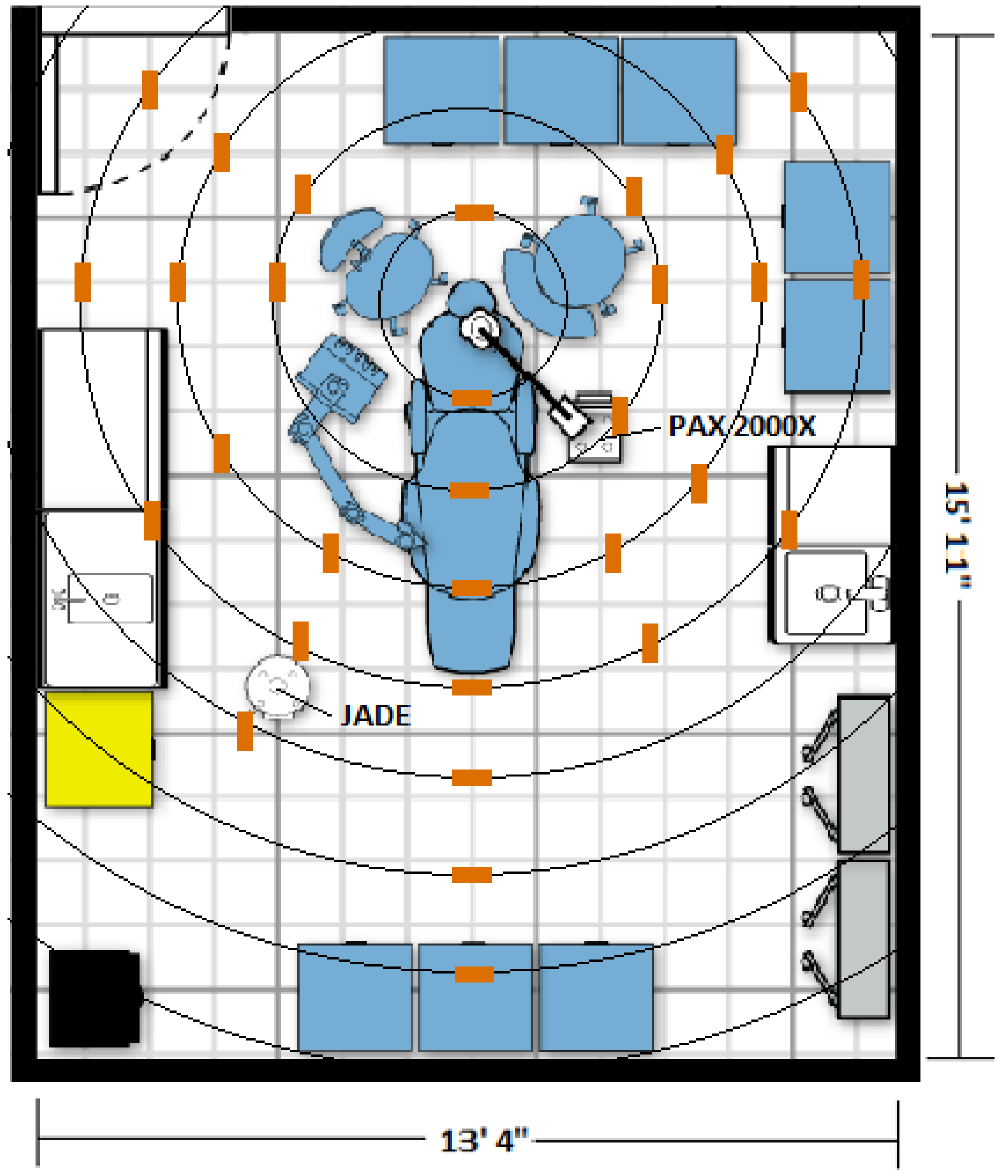


Figure 3. Operatory UIP strip placement. Moving out from the center (simulated patient's head) circles diameter increases by 3 feet.[14] Strips were placed on the floor and surfaces pictured. Created using 2020 Icovia Room Planner (https://henryschein.icovia.com/)[13]

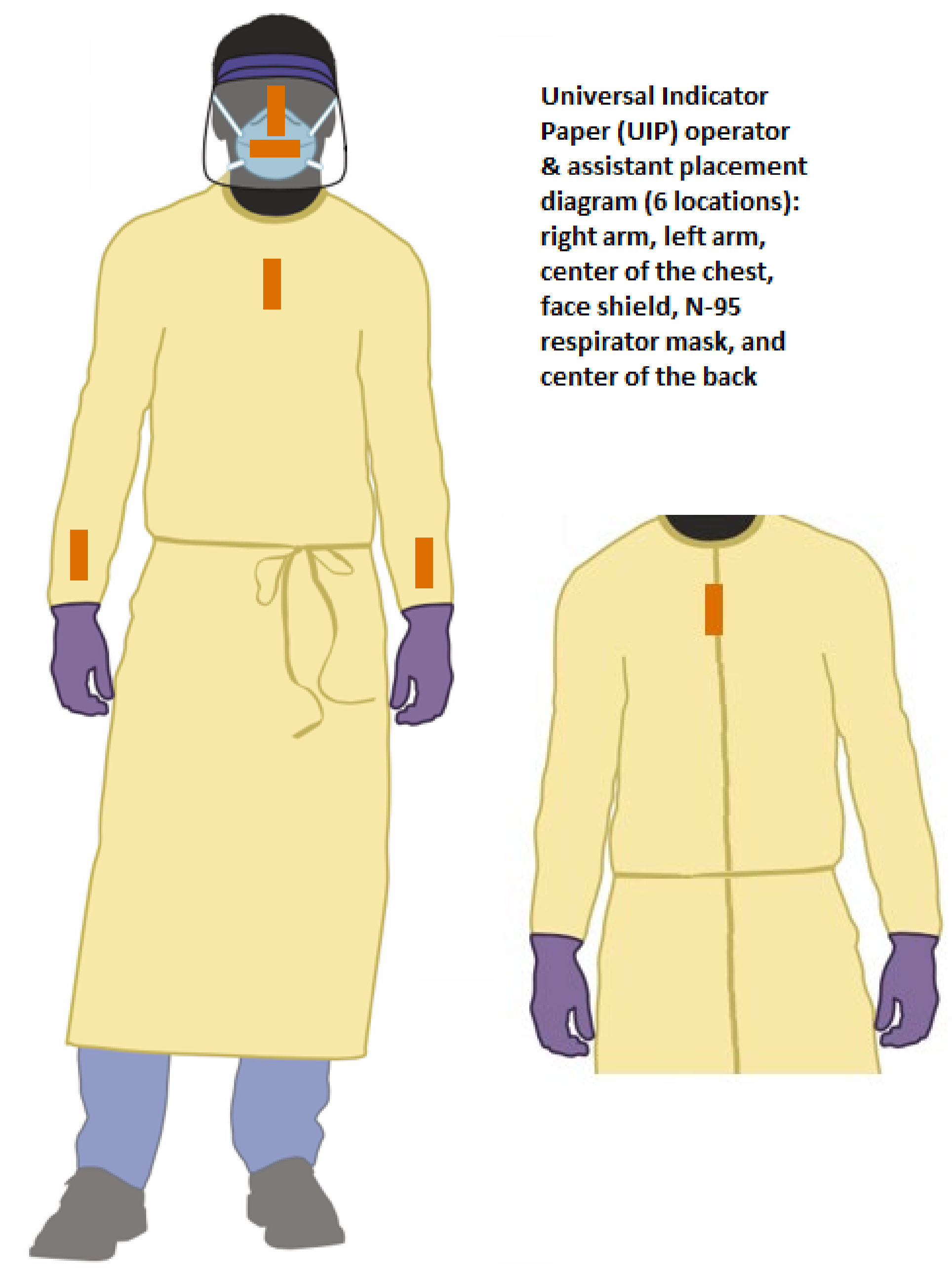
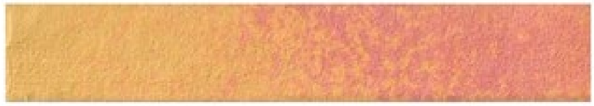


Figure 4. Provider and assistant UIP strip placement. Universal indicator paper (UIP) placed on the provider (six), and on the assistant (six). Modified image from the CDC Coronavirus disease 2019 (COVID-19) Factsheet[15]

The pH of a 0.541310M citric acid solution is approximately 1.71, while UIP has a pH sensitivity range of 1-14; contaminated UIP will change from its baseline color primarily #d8a860 (hexadecimal color value) to #f09078 upon contact with citric acid (Figure 5).



Color	Color Code	Percentage
	#d8a860	0.512533
	#f09078	0.486933

Figure 5. UIP strip analysis. UIP sample strip when directly sprayed with the study handpiece and solution. UIP strips were inspected, scanned at 1200 dpi (Cannon Pixma Ts6420) and analyzed (Image Color Extract, www.coolphptools.com)[16] for percentage contamination after each test. Image Color Extract calculates a hexadecimal color values from submitted samples and returns percentage values.

To determine effectiveness of the aerosol-mitigation devices, a baseline was established by collecting contaminated UIP after each of five test procedures performed with only the standard high-volume ejector and saliva ejector aerosol-mitigating devices (Control group). Three additional procedures were to then be performed with the addition of the Jade Air Purifier (Test group #1), addition of the PAX 2000X (Test group #2), and finally the Jade Air Purifier and PAX 2000X used in combination (Test group #3). Data collected was to be reported as seen for further analysis (Table 1).

Table 1. Data Collection Sheet. Contamination percentage between procedures. Results reported for operatory, operator, and assistant sites separately

Results for each site	**Control**	**Jade**	**PAX**	**Combination (Jade + PAX)**	**Difference from control**	**Reduction (%) from control**
Mean operatory site contaminated (n)						
Mean percentage intensity of operatory contamination						
Mean operator site contaminated (n)						
Mean percentage intensity of operator contamination						
Mean assistant site contaminated (n)						
Mean percentage intensity of assistant contamination						

Typodont tooth #19 was to be prepared a total of 20 times, UIP was to be collected, inspected, scanned (Cannon Pixma Ts6420, Melville, NY) at 1200 dpi and analyzed (Image Color Extract, www.coolphptools.com) for percentage contaminated after each test. Image Color Extract calculates a hexadecimal color values from submitted samples and returns percentage values (i.e.: Color Code: #f0a800, Percentage: 0.229702).

Prior to the testing an anemometer (TSI Incorporated, 9535-A, Shoreview, MN) was used to determine the operatory air changes per hour (ACH) to be approximately three. Based on the measured ACH, the CDC recommendation for time required for airborne-contaminant removal with 99% efficiency falls between 69 and 138 minutes.[17] This recommendation was based on the assumption that the room was empty and no aerosol generating source was present. Therefore, at the conclusion of each closed door simulation, the operator and the assistant left the room and the calculated 100 minutes was allowed to pass uninterrupted for airborne particles to settle.

CHAPTER 3: Results

Typodont tooth #19 was prepared for five minutes under our control group conditions (utilizing high-volume ejector and saliva ejector only). Under these conditions five iterations were completed for a total of 25 minutes of tooth preparation utilizing a total of 210 UIP test strips. No visible contamination was noted on any of the UIP strips during any of the five test iterations. The closest UIP strip to the aerosol producing handpiece was on the provider's right arm, approximately 7 inches away. Based on our control group findings, testing with additional mitigation devices (PAX 2000X, Jade Air Purification, combination) was deemed not beneficial. Therefore test groups #2, #3, and #4 were not conducted. Statistical analysis was not conducted as quantitative data was not available. Visual (photographic) qualitative data was collected for interpretation-based presentation (Figures 6-8).

Photos courtesy of Dr. Teutsch, Shawn Douglas

Figure 6. High Speed Handpiece Aerosol Production. Visual representation of aerosol/spatter production by the NSK-NL-85M high speed handpiece (444,000 rpm, 88ml/min). No mitigation devices in use. The PAX 2000X unit pictured is not operating (power setting set to off) at the time of the photograph. The handpiece was held away from the working field (tooth #19) for visual, photographic demonstration.

Photos courtesy of Dr. Teutsch, Shawn Douglas

Figure 7. Control Conditions. Visual representation of aerosol/spatter production by the NSK-NL-85M high speed handpiece (444,000 rpm, 88ml/min). Mitigation via high-volume ejector and saliva ejector only, PAX 2000X and Jade Air Purification units not being utilized. The handpiece was held away from the working field (tooth #19) for visual, photographic demonstration.

Photos courtesy of Dr. Teutsch, Shawn Douglas

Figure 8. PAX 2000X. Visual representation of aerosol/spatter production by the NSK-NL-85M high speed handpiece (444,000 rpm, 88ml/min). Mitigation via PAX 2000X only. This photo demonstrates visually, grossly how effective the PAX 2000-X can be in a two-handed, single provider setting, working along with no dental assistance. The handpiece was held away from the working field (tooth #19) for visual, photographic demonstration.

CHAPTER 4: Discussion

The initial hypothesis that dental procedures utilizing a high-speed handpiece would produce a large amount of aerosols and would result in significant spread throughout the dental treatment operatory was partially accepted. Capturing images of the high-speed handpiece produced aerosols demonstrates visually and qualitatively the potential risk associated with introducing potentially infectious particles into the air. However, measureable spread of aerosols during this study was not observed. Absence of contamination of UIP and images captured under control conditions demonstrate lack of significant spread of dental procedure produced aerosols.

The high-speed handpiece was chosen for use in this study as it is the primary instrument used by dentists for tooth preparation. Additionally the high-speed handpiece has been shown to produce more and spread aerosols to a greater distance when compared to other dental instruments (contra-angle handpiece, ultrasonic scaler, air polishers, air abrasion units, etc.).[18, 19] A citric acid solution and UIP were used during this study as they have been shown to be a reliable method for producing, measuring, and collecting quantitative data for analysis regarding the spread of dental procedure produced aerosols.

This study was modeled closely after the Shahdad *et al* study which found that extraoral scavenger (EOS) devices significantly reduce the frequency and mean intensity of contamination within a dental operatory. That study however was vague in limiting its conditions, conducting full-mouth supragingival scalings with an ultrasonic scaler, air turbine procedures, and surgical procedures. The setting for the procedures were either in an open style operatory or a closed surgery style operatory. Time required to complete each procedure varied and procedures were conducted with or without an assistant. Unlike the findings in this study, the citric acid solution used in that study contaminated the UIP, data was gathered and conclusions were drawn.[19]

Lonescu *et al* went further, utilizing *Streptococcus mutans* and agar plates to examine the spread of procedure produced aerosols. The conditions for the study like the Shahdad *et al* were not limited in scope and tested various procedures utilizing several different dental instruments (air turbine handpiece, contra-angle handpiece, and ultrasonic scaler). The study makes no mention of an assistant or the utilization of aerosol mitigation strategies.[18]

Significant limitation when conducting this study inhibit our ability to make definitive conclusions. Variations in conditions to include, but not limited to, operatory size, layout, ventilation, room temperature, humidity, etc., could significantly impact the outcome. The use of different equipment to include, but not limited to, the handpiece (high-speed, contra angle, ultrasonic scaler or Cavitron), bur, dental chair, rubber dam, Isolite, etc., could also play a role in production and propagation of procedure driven aerosol production. The dental procedure selected for this study was limited to a single posterior tooth preparation under rubber dam isolation utilizing a four-handed dentistry (assistant and provider working together) approach.

A dental treatment team has the ability to provide care for the entirety of a patient's complex oral and maxillofacial environment, perform a vast number of clinical procedures (tooth preparation, scaling, and/or surgical procedures), while utilizing a wide variety of different dental instrumentation. Dental procedures can also be performed by a solo provider, dentist or hygienist. The use of the PAX 2000X could have a demonstrated benefit to a care provider working without an assist available to manage the high-volume ejector and saliva ejector.

CHAPTER 5: Conclusions

Within the limitations of this study, it can be concluded that utilizing standard mitigation strategies to include rubber dam isolation, high-volume suction and saliva ejector dramatically reduce the propagation of high speed handpiece dental procedure produced aerosols. Additional in-vitro/in-vivo studies examining various conditional and environmental parameters are needed to support clinical recommendations.

REFERENCES

1. World Economic Forum Which jobs are most damaging to your health? : 2015, November 11. "https://www.weforum.org/agenda/2015/11/which-jobs-are-most-damaging-to-your-health/".

2. Kohn WG, Collins AS, Cleveland JL, et al. Guidelines for infection control in dental health-care settings--2003. MMWR Recomm Rep 2003;52(RR-17):1-61.

3. Harrel SK, Molinari J. Aerosols and splatter in dentistry: a brief review of the literature and infection control implications. J Am Dent Assoc 2004;135(4):429-37.

4. World Health Organization Considerations for the provision of essential oral health services in the context of COVID-19. 2020 August 3. "https://www.who.int/publications/i/item/who-2019-nCoV-oral-health-2020.1".

5. Centers for Disease Control and Prevention Revised U.S. Surveillance Case Definition for Severe Acute Respiratory Syndrome (SARS) and Update on SARS Cases --- United States and Worldwide, December 2003. 2003 December 12. "https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5249a2.htm".

6. Peiris JS, Poon LL. Detection of SARS coronavirus. Methods Mol Biol 2011;665:369-82.

7. Prevention CfDCa. COVID Data Tracker. 2021.

8. American Dental Association ADA recommending dentists postpone elective procedures. 2020 March 16. "https://www.ada.org/en/publications/ada-news/2020-archive/march/ada-recommending-dentists-postpone-elective-procedures".

9. Sterisil Sterisil System G4. 2019. "https://www.sterisil.com/sterisil-system".

10. A-dec Inc. JADE Air Purifier by Surgically Clean Air.: 2021. "https://www.a-dec.com/air-management/jade".

11. Qiao B, Olvera de la Cruz M. Enhanced Binding of SARS-CoV-2 Spike Protein to Receptor by Distal Polybasic Cleavage Sites. ACS Nano 2020;14(8):10616-23.

12. Integrum 3D LLC. PAX2000X Extraoral Dental Suction System. 2021. "https://integrum3d.com/product/pax2000x-extraoral-dental-suction-system/".

13. Icovia Icovia Space Planner. 2020 Icovia 2020. "https://henryschein.icovia.com/".

14. Wells WF. Airborne Contagion and Air Hygiene. 1955.

15. Prevention CfDCa. Use Personal Protective Equipment (PPE) When Caring for Patients with Confirmed or Suspected COVID-19. 2020.

16. Tools CP Cool PHP Tools. 2022. "https://www.coolphptools.com/". 2022.

17. Prevention CfDCa Airborne Contaminant Removal. "https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html#tableb1".

18. Ionescu AC, Cagetti MG, Ferracane JL, Garcia-Godoy F, Brambilla E. Topographic aspects of airborne contamination caused by the use of dental handpieces in the operative environment. J Am Dent Assoc 2020;151(9):660-67.

19. Shahdad S, Patel T, Hindocha A, et al. The efficacy of an extraoral scavenging device on reduction of splatter contamination during dental aerosol generating procedures: an exploratory study. Br Dent J 2020.