อนุภาคของละอองฝอยที่เกิดขึ้นระหว่างกระบวนการศัลยกรรมช่องปาก

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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Generated aerosol particles during oral surgery procedures

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หัวข้อวิทยานิพนธ์	อนุภาคของละอองฝอยที่เกิดขึ้นระหว่างกระบวนการศัลยกรรมช่องปาก
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ดิษธร สังแก้ว : อนุภาคของละอองฝอยที่เกิดขึ้นระหว่างกระบวนการศัลยกรรมช่องปาก. (Generated aerosol particles during oral surgery procedures) อ.ที่ปรึกษาหลัก : ผศ. ทพญ. ดร.ภัคสินี กมลรัตนกุล, อ.ที่ปรึกษาร่วม : ผศ. ทพ.กิติ ศิริวัฒน์

โรคติดต่อหลายโรครวมถึงโรคติดเชื้อไวรัสโคโรนา2019, วัณโรค และโรคไข้หวัดใหญ่สามารถแพร่กระจายการติดต่อได้ทางละอองชีวภาพจากผู้ป่วย การศึกษาเพื่อการหามาตรการจัดการที่เหมาะสมที่แต่เดิมใช้วิธีการตรวจหาการแพร่กระจายของจุลชีววิทยาและการปนเปื้อนของโลหิตถูกเปลี่ยนไปเป็นหลักการฝุ่นละอองขนาดเล็ก การรักษาทางทันตกรรมนับว่าเป็นส่วนหนึ่งของหัตถการที่ก่อให้เกิดละอองฝอยดังกล่าว แต่พบว่ามีการศึกษาที่เกี่ยวข้องกับศัลยกรรมช่องปากจำนวนน้อยมาก โดยส่วนใหญ่งานวิจัยที่เกี่ยวข้องในเรื่องของละอองชีวภาพที่เกิดจากทันตกรรมจะมุ่งไปที่การรักษาในทางทันตกรรมหัตถการและปริทันต์ งานวิจัยนี้มีจุดประสงค์คือต้องการที่จะใช้หลักการฝุ่นละอองขนาดเล็กในการวัดปริมาณของละอองชีวภาพที่เกิดขึ้นจากหนึ่งในกระบวนการศัลยกรรมช่องปากคือการตัดฟัน โดยงานวิจัยนี้จะเป็นไปในรูปแบบการทดลองตัดฟันในระบบปิดจากการใช้เครื่องมือ 3 ชนิด คือ 1.หัวกรอเร็ว 2.เครื่องพีโซอิเล็กทริค 3.หัวกรอไมโครมอเตอร์ เป็นเวลา 1 นาที และวัดปริมาณละอองชีวภาพที่เกิดขึ้นในรูปแบบของ ฝุ่นละออง PM1, PM2.5 และ PM10 ด้วยเครื่องวัดอนุภาคในอากาศ โดยผลการวิจัยพบว่าการใช้เครื่องมือทั้ง 3 ชนิดในการตัดฟันสามารถสร้างละอองชีวภาพขึ้นอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.001 ปริมาณละอองชีวภาพทั้ง PM1, PM2.5 และ PM10 สูงสุดเกิดจากการใช้หัวกรอเร็วตามมาด้วยการใช้เครื่องพีโซอิเล็กทริคและหัวกรอไมโครมอเตอร์ตามลำดับ โดย ณ เวลาที่ปริมาณละอองชีวภาพสูงสุดของแต่ละการใช้เครื่องมือทั้ง 3 ชนิดจะมีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.001 และการใช้หัวกรอเร็วจะต้องการเวลามากที่สุดโดยใช้เวลา 16 นาที 40 วินาที เพื่อให้ค่าละอองชีวภาพกลับสู่ค่าเริ่มต้น ในขณะที่การใช้เครื่องพีโซอิเล็กทริคใช้เวลา 13 นาที 20 วินาที และการใช้หัวกรอไมโครมอเตอร์จะใช้เวลา 8 นาที 20 วินาที นอกจากนี้จากการวิจัยพบว่า กระบวนการตัดฟันโดยการใช้หัวกรอไมโครมอเตอร์จะสร้างละอองชีวภาพน้อยที่สุดและไม่เกินข้อกำนดคุณภาพอากาศในอาคารขององค์การอนามัยโลก ขณะที่การใช้หัวกรอเร็วและเครื่องพีโซอิเล็กทริคจะสร้างละอองชีวภาพในปริมาณที่สูงกว่าข้อกำหนดคุณภาพอากาศในอาคารดังกล่าว การจัดการอากาศอย่างเหมาะสมควรจะถูกพิจารณามาใช้เพื่อป้องกันการติดต่อโรคติดเชื้อทางอากาศ โดยเฉพาะในระหว่างการใช้หัวกรอเร็วและเครื่องพีโซอิเล็กทริคในการตัดฟัน และควรจะมีการกำหนดมาตรฐานระดับปริมาณของละอองชีวภาพที่เหมาะสมในคลินิกทันตกรรม

สาขาวิชา	ศัลยศาสตร์ช่องปากและแม็กซิลโลเฟเชียล	ลายมือชื่อนิสิต ....
ปีการศึกษา	2566	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
		ลายมือชื่อ อ.ที่ปรึกษาร่วม ....

6370009632 : MAJOR ORAL AND MAXILLOFACIAL SURGERY

KEYWORD: COVID-19, Aerosol-generating procedures(AGPs), Bioaerosols, Particle matter, Oral surgery

Dissatorn Sangkaew : Generated aerosol particles during oral surgery procedures. Advisor: Asst. Prof. PAKSINEE KAMOLRATANAKUL, D.D.S., Ph.D. Co-advisor: Asst. Prof. KITI SIRIWATANA, D.D.S.

Purpose: This study aimed to measure the quantity of bioaerosol generated during tooth-cutting procedures in oral surgery treatments using the concept of particulate matter (PM).

Methods: In this experiment, a closed system (plastic box) replicated the tooth-cutting procedure. Three instruments (airotor, piezoelectric device, and micromotor) were used for one minute each. Bioaerosol quantity was measured using an air particle counter, assessing PM1, PM2.5, and PM10 levels. Differences between procedures were compared using one-way ANOVA test. Statistical significance was set at 95%.

Results: All three instruments generated bioaerosols significantly ($p < 0.001$). The airotor exhibited the highest levels of PM1, PM2.5, and PM10, followed by the piezoelectric device and the micromotor. Specifically, for PM2.5, the airotor produced 238.30 ± 69.66. The piezoelectric device produced 132.57 ± 91.05, and the micromotor generated 8.71 ± 7.20. Both airotor and piezoelectric instruments exceeded WHO indoor air quality guidelines for PM2.5 and PM10. However, the micromotor consistently generated aerosols regardless of speed.

Conclusion: The micromotor had the lowest bioaerosol generation during tooth-cutting oral surgery. Effective air management, especially with piezoelectric devices, is crucial. It is recommended to avoid using the airotor in oral surgery. Standardized aerosol levels are important for ensuring safety in dental clinics.

Field of Study:	Oral and Maxillofacial Surgery	Student's Signature ....
Academic Year:	2023	Advisor's Signature ....
		Co-advisor's Signature ....

กิตติกรรมประกาศ

งานวิจัยเรื่อง อนุภาคของละอองฝอยที่เกิดขึ้นระหว่างกระบวนการศัลยกรรมช่องปาก สามารถดำเนินการจนสำเร็จลุล่วงไปด้วยดี เนื่องจากได้รับการอนุเคราะห์และสนับสนุนเป็นอย่างดียิ่งจาก ผศ.ทพญ.ดร.ภัคสินี กมลรัตนกุล และผศ.ทพ.กิติ ศิริวัฒน์ อาจารย์ที่ปรึกษาวิทยานิพนธ์หลักและอาจารย์ที่ปรึกษาวิทยานิพนธ์ร่วม ที่ได้กรุณาให้คำปรึกษา ความรู้ คำแนะนำ เพื่อนำไปปรับปรุงแก้ไขข้อบกพร่องต่างๆจนกระทั่งการวิจัยครั้งนี้สำเร็จเรียบร้อยดี รวมไปถึง ผศ.ทพญ.ดร.สรนันทร์ จันทรางศุ ที่ได้กรุณาให้คำปรึกษาเกี่ยวกับการใช้สถิติเพื่อการวิจัย และอาสาสมัครผู้มอบฟันตัวอย่างที่นำมาใช้ในงานวิจัยครั้งนี้ ผู้วิจัยขอกราบขอบพระคุณเป็นอย่างสูงไว้ ณ ที่นี้

ดิษธร สังแก้ว

สารบัญ

หน้า

Chapter I

Introduction

1.1 Background and Rationale

According to a statement published by the World Health Organization (WHO) in July 2020, Coronavirus disease(COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is spread by respiratory droplets and contact routes. Contact with droplets, which are airborne particles smaller than 5 micrometers[1], is one of the factors that enables the disease to spread rapidly. The smaller the droplets are, the longer they remain in the environment. The aerosols can be created by the patient directly, while they cough, sneeze, or talk[2], as well as through medical interventions like intubation[3] and dental procedures[4].

Moreover, many diseases, including TB and influenza, might be transmitted through the aerosol that contains pathogens such as bacteria or viruses that can be inhaled through the respiratory tract and cause the disease[5, 6]. The aerosol that contains microorganisms both pathogenic and non-pathogenic can be called “Bioaerosols”[7]. Bioaerosols originate from living organisms in small airborne particles and can spread easily because of their size (ranging from 0.001 to 100 micrometers)[8, 9]. The cause of bioaerosols can be from the host’s activities and the procedure to them such as treatment or experiment[10, 11]. Many treatments including dental treatment can be determined as “Aerosol-generating procedures” (AGPs) because of the use of some instrumentals such as airotor or ultrasonic scaling[12, 13].

The generation of bioaerosols during several dental procedures is observed. Since the height of the tuberculosis (TB) pandemic, research has been conducted about bioaerosols from dental procedures[12]. Further study is then performed, frequently using the fundamental microbiology measurement technique and the study of microorganisms[14-25]. Eventually, during a COVID-19 outbreak, the study of Akin H et al.[26] actually studied COVID-19 patients, conducted by researchers who have performed dental procedures on patients who have been admitted with COVID-19 disease and documented aerosol data. When investigating the duration of the operative and periodontal treatments, it can be determined that SARS-CoV-2, which causes COVID-19, is found on the surface of the dental clinic room.

While the majority of previous research studies have concentrated on operative and periodontal treatments. They determined the amount of aerosol when performing cavity preparation in teeth by using the airotor and removing calculus with an ultrasonic scaler[16-25]. However, there are a few studies on oral surgery[14, 15] and one of the study is the Gallagher et al. study[14]. A systematic review was conducted, and it was discovered that most of the research investigated was about microbiology and blood contamination. They also found that oral surgery procedures produce bioaerosol, but in a smaller amount. Moreover, most of the studies in this research were focused on the surgical removal of impacted teeth by only using the micromotor[14, 15, 27]. However, some dentists may use the airotor for tooth-cutting procedures[25] and with the increase in popularity of using piezoelectric[28], the use of the airotor or piezoelectric was not included in this study.

The measurement of bioaerosol from dental procedures can be performed in a variety of ways. Previously, most of the observations were based on microbiology and blood contamination[14-24], but now there are new assessment methods that use the particle matter principle. The mechanism of this method is to release a laser into the air and then using a receiver to measure the particles in the air when the laser scatters when it hits a particle in the air[29]. In addition, various particle sizes were measured, including PM1 (less than 1 micrometer), PM2.5 (1.0-2.5 micrometers), and PM10 (2.5-10 micrometers)[30]. Moreover, from WHO statement, bioaerosol that less than 5 micrometers can be considered as an infected bioaerosol and cause respiratory disease infection[1, 8].

Furthermore, the size of the particles has significant effect. Airborne particles smaller than 10 micrometers can pass through the respiratory tract, and particles smaller than 2.5 micrometers can penetrate deeper into the alveoli of the lungs and may also enter the circulatory system through alveolar capillaries, inducing lung and systemic inflammation[31, 32]. Moreover, WHO declared the influence of aerosol on the transmission of airborne diseases and classified respiratory droplets as particles generated by sneezing, coughing, or breathing that are sized between 5 and 10 micrometers, with those smaller than 5 micrometers referred to as aerosols or droplet nuclei[1] and they can be determined as bioaerosols because they were made from living organism[7]. Furthermore, many human diseases, both infectious and non-infectious diseases such as pneumonia, influenza, measles, asthma, allergies can be related to the presence of bioaerosols[5].

Since the COVID-19 pandemic, the concentration of airborne bioaerosols research involving dental procedures has shifted from microbiology to particle matter, with most research performed in models to study aerosol distribution, including research on the use of different systems, such as suction, the use of several types of air purifiers, and airflow systems, as well as studies that were mainly focused on the study of operative and periodontal procedures[33-35].

However, there are few studies in the field of oral surgery procedures, and none of them use particle matter principles. Therefore, this study aims to investigate aerosol generation from the procedure of oral surgery. The study approach was different from the previous one by applying the particle matter principle and evaluating the generation of aerosol utilizing various surgical instruments including micromotor, piezoelectric, and airotor. We expect that this study will be utilized to create strategies or methods to prevent disease transmission caused by bioaerosols during oral surgery.

1.2 Research questions

- Is there a difference in the amount of aerosol that each type of oral surgery instrument produces?
- Is there any difference in duration required to return to the baseline value of aerosol by each type of oral surgery instrument?

1.3 Research objectives

- To measure the amount of aerosol produced by various types of equipment during the tooth-cutting procedure in oral surgery.
- To evaluate the time required for each type of oral surgical instrument to return to the baseline value of aerosol.

1.4 Research design

- Experimental study

1.5 Benefit of study

- The findings of this study can be used to develop appropriate dental treatment guidelines for personal protective equipment, engineering control, standard operating procedures for infection control, and so on, not only for the COVID-19 pandemic but also for several kinds of other airborne infectious diseases.

1.6 Operational definition

- **COVID-19**: referred from Coronavirus disease is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).
- **Aerosol-generating procedures(AGPs)** are medical procedures that can result in the release of aerosols from respiratory tract.
- **Bioaerosols** are the aerosol that contains microorganisms both pathogenic and non-pathogenic.
- **Particle matter** is the term for a mixture of solid particles and liquid droplets found in the air, such as dust, dirt, soot, or smoke.
- **Oral surgery** is a surgical operation performed in the oral cavity to resolve or remove pathological anatomical abnormalities.

1.7 Limitation

- The experiment is carried out in a control chamber in order to regulate factors that affect the amount of particulate matter, such as external salivary suction devices, air conditioners, and air purifiers, thus there may be variances from actual clinical practice.

Chapter II

Literature review

2.1 COVID-19

Nowadays, the pandemic of COVID-19 disease is still widespread. On December 31, 2019, there were 27 cases of pneumonia in Wuhan, China, and Chinese center for disease control and prevention-CCDC-labeled the disease “Severe Acute Respiratory Syndrome Coronavirus2(SARS-CoV-2)”. Likewise, the World Health Organization has designated this disease as “COVID-19” and declared a Public Health Emergency of International Concern for the COVID-19 outbreak in China on January 30, 2020. In addition, they explained that SARS-CoV-2 virus that causes COVID-19 is a betacoronavirus, which is similar to other SARS corona viruses because they both are Single-stranded ribonucleic acid (RNA) viruses[36].

Thereafter, Letko M et al. conducted computer-modelling experiments and discovered that coronavirus entry into human cell is a multi-step process related to the glycoprotein at the area known as “Receptor-binding domain (RBD)” or the spike protein of virus that engage to the human cell surface at the receptor known as “Angiotensin Converting Enzyme 2” or “ACE2” and activate protease processing and then fuse to the membrane[37]. Moreover, ACE2 was found abundantly in the human respiratory tract and in salivary gland ducts at the area of epithelial lining cells[38].

To better understand the pathogenesis of the SAR-CoV virus, Hamming I et al. discovered that the presence of the ACE2 protein on the surface of lung alveolar epithelial cells and small intestine enterocytes, i.e., cells in contact with the external environment, is the most significant finding. Furthermore, SARS-CoV is transmitted via the respiratory tract. In a recent autopsy series involving viral isolation, culture methods, and in situ hybridization, SARS-CoV was discovered in pneumocytes. These findings, combined with the fact that ACE2 is the functional CoV receptor for SARS, imply that alveolar pneumocytes in the lungs may represent a viable entry point for the virus. Additionally, this expression pattern may contribute to the rapid progression of pathological lung symptoms. Upon Initial viral entry, cytopathological changes at the epithelial alveolar-capillary interface may occur, inducing type II alveolar cells as a first line of defense. ACE2 expression in type II alveolar cells is high during SARS, which may contribute to rapid viral replication and a vicious cycle of local alveolar wall degradation, resulting in rapid escalation, severe, and widespread alveolar damage[39].

Controlling indoor respiratory aerosol concentrations is critical for preventing infectious agent airborne transmission. This can be accomplished through source control (masking, physical distancing) and engineering controls (ventilation and filtration). The protocols to reduce far-field airborne transmission of SARS-CoV-2 and other airborne infectious diseases in small-volume indoor spaces are 4 to 6 air changes per hour combined with outdoor air ventilation, recirculated air that passes through a central filter with at least a minimum efficiency rating value of 13 (MERV 13) rating or the use of high-efficiency particulate air (HEPA) filters. The oral surgery treatment room, on the other hand, lacks a ventilation system and filtration protocols[40].

2.2 Mode of transmission of COVID-19

The transmission of COVID-19 is one of the topics that has been studied since this disease outbreak. One of the early review papers was from Peng X et al.[13], this paper suggested that possible transmission routes of COVID-19 included airborne spread, contact spread and contaminated surface spread while the aerosol transmission remains unknown. However, in some circumstances, the possibility of airborne dissemination during aerosol-generating practices remains a concern[41]. Furthermore, Liu Y et al.[42] studied about the aerodynamic analysis of SARS-CoV-2 and showed that the virus particle was mostly found in two sizes, one is sub micrometer region and the other is super micrometer region. They believed that the virus aerosol in the sub micrometer region was generated by the patient's respiratory droplets and the virus in the super micrometer region was deposited on the floor. In addition, they suggested that SARS-CoV-2 was biologically stable for hours to 15 days due to their formation of aerosols and on different surfaces.

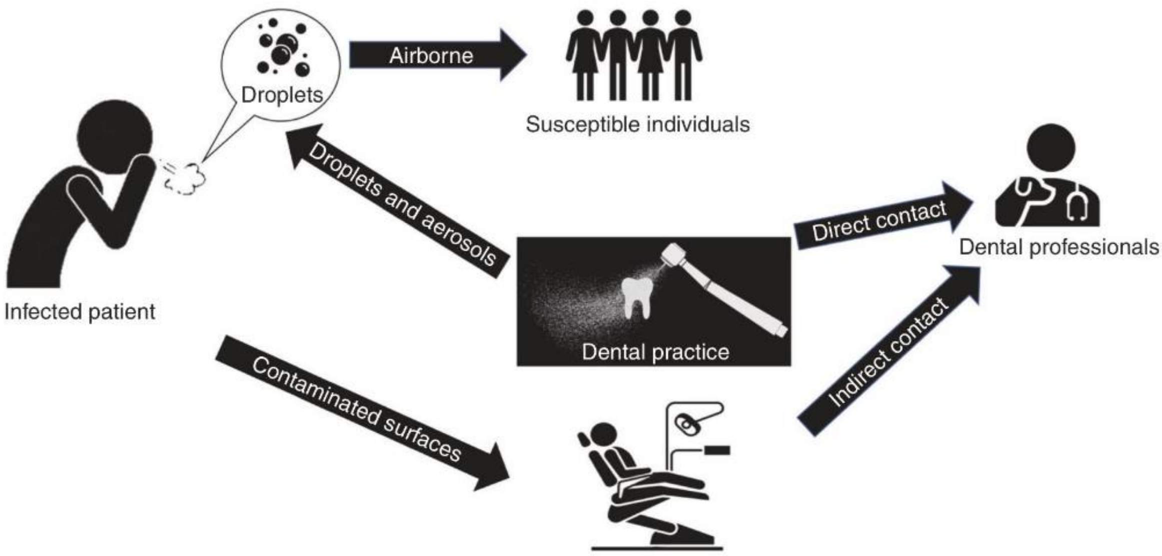

Figure 1. Illustration of transmission routes of SAR-CoV-2 in dental clinics

According to the World Health Organization (WHO) statement, the possible mode of transmissions of the SARS-CoV-2 is through direct, indirect, or close contact with infected people. They discovered that Infected secretions such as saliva and respiratory secretions or their respiratory droplets are the main infectious agent. Moreover, one of the transmission modes of Covid-19 may be airborne transmission during aerosol generating procedures from medical practices or non-aerosol generating procedures in poorly ventilated rooms[1].

Similar to the Centers for Disease Control and Prevention (CDC), they suggested that COVID-19 appeared to be transmitted via the exposure to respiratory fluids containing infectious virus which they classified into three pathways: the first is inhalation of infectious virus from air carrying virus contaminated droplets and aerosol particles, the second is virus deposition onto exposed mucous membranes from exhaled droplets and particles, and the third is touching mucous membranes with virus-infected hands from exposure of exhaled respiratory fluids or from touching virus contaminated surfaces[43].

In addition, there is a study that investigated the stability of SARS-CoV-2 aerosols and the authors discovered that the SARS-CoV-2 virus remained in the aerosol for hours, potentially increasing risk of infectious[44]. Based on current epidemiography data, Chen et al.[45] discovered in 2020 that SARS-CoV-2 has higher potential to transmit than SAR-CoV and MERS-CoV.

2.3 Current guidelines for dental health care providers

The risk of developing COVID-19 for dental health care providers is the highest of all professions because of the lengthy and direct face-to-face interactions between the dentist and the patient, as well as the dental assistant and the patient[46, 47]. As a result, the CDC developed the guideline for dental settings in COVID-19 pandemic. They considered that the transmission of virus can be persist in the form of aerosols for hours and for days when the virus is on the surface. To eliminate the virus aerosols, they advised maintaining ventilation systems air flow and placing the High Efficiency

Particulate Air filter (HEPA) air filtration near the patient's chair, but not behind the dental health care providers[43].

Similarly to the California Dental Association, they developed the CDC guideline and suggested to zones for aerosol management (Figure 2). The goal of this consideration was to provide the procedures in each zone because they believed it was more effective for dental health care providers, patients, and the people who were not in the dental room[48].

Figure 2. 4 zones of conceptualized to air and aerosols in dental offices management

Furthermore, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) was one of the aerosol management agencies that recommended to use using air filtration and upper room Ultraviolet Germicidal Irradiation (UVGI) to reduce infectious aerosols not only for COVID-19, but also other airborne infectious disease and they rated this procedure as the level B of evidence level[49].

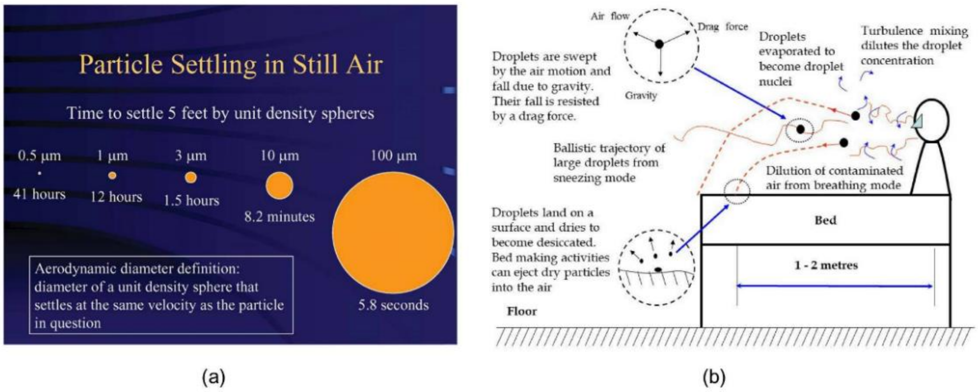

Figure 3. (a) Comparative settling times by particle diameter and (b) mechanism of transmission of droplets and small airborne particles generated by acute infected patient

Besides, Air ventilation in dental clinics is an important method particularly during a severe respiratory pandemic like COVID-19. To get enough airflow, you'll need either natural ventilation or a mechanical system. Bringing fresh air into operating rooms by opening windows on a regular basis may help to dilute virus-laden particles in the air. Meanwhile, indoor air purifiers are an efficient additional intervention for dental clinic workers to improve air quality and significantly reduce aerosol exposure[50, 51]. When a patient is suspected of having COVID-19, mechanical ventilation at a rate of 6 air changes per hour is recommended both during and after the visit[52]. The key strategies for assuring occupational safety during the current pandemic are frequent air exchange with mechanical ventilation and repeated disinfection of air-conditioning systems in dental clinics[47]. Increased ventilation (fresh air) has been shown to eliminate infectious viruses and particles, reducing the risk of transmission. Figure 4 depicts the time required to remove an airborne contaminant and the importance of ventilation quality and air change rates in reducing the risk of Covid-19 transfer via aerosol[53].

ACH § ¶	Time (mins.) required for removal 99% efficiency	Time (mins.) required for removal 99.9% efficiency
2	138	207
4	69	104
6+	46	69
8	35	52
10+	28	41
12+	23	35
15+	18	28
20	14	21
50	6	8

Figure 4. Table of air change/hour (ACH) and time required for airborne-contaminant removal by efficiency from the CDC guideline

2.4 Dental aerosol

In 2004, Harell S K et al. published a review article of dental aerosol with the goal of recommending a protocol to control dental aerosol. They defined aerosol as particle with a diameter of less than 50 micrometers that, if small enough, would likely stay in the air for extended time. If the particle’s diameter is larger than 0.5 micrometers, it is classified as splatter and this particle most commonly found on surface's floor because of its size that reduces time to stay in air and fall to the floor due to gravity. Moreover, they revealed that infectious substances such as bacteria, viruses, Tuberculosis, common cold, influenza, Herpes viruses, pathogenic streptococci, and SARS virus are found in the oral cavity fluid. As a result, dental aerosols and splatters have the potential to spread infection. This paper recommended protocols when the dental aerosol was produced such as using mouth rinse to eliminate infectious substances before dental procedures, using rubber dam, using extra-oral suction, etc. [12].

Rautemaa R et al.[18] discovered that the most microbes in dental aerosol are *Viridans streptococci* and s*taphylococci*, besides, the contaminated area was 1-1.5 meters away from the operating site, and the majority of the contamination was caused by the use of high-speed instrument. According to Zemouri et al.[19], there are 38 types of microbes in the air of dental clinic, and *Legionella pneumophilia* is one of these microbes that cause severe pneumonia.

2.5 Dental aerosol related to oral surgery treatments

During the COVID-19 pandemic, most of dental procedures involving an emergency or urgent case were related to oral surgery. Therefore, many researchers studied the risk of infectious aerosol from oral surgeries, one of whom was Gallegher J E et al.[14] In COVID-19 pandemic, they conducted a systematic review of contamination in formation of aerosol, splatter and droplet associated with oral surgery. The purposes of this study were to define the pattern of aerosol spreading, to determine the relationship between exposure, infection, and transmission, and to identify the type of microorganism and measurement methods. Furthermore, they discovered that the majority of the studies concluded in their systematic review were observational studies completed prior to the COVID-19 pandemic, and the methodology used was mostly measurement of bacterial contamination by using blood agar plates, followed by aerobic incubation and counting for bacterial colonies. The second most commonly used methodology was blood contamination, which was measured using a visual and chemical reagent. According to the findings of this systematic review, the zone of microbial and blood contamination extended up to one meter from the operation site.

However, there were a lot of limitations of the studies which were included in this systematic review. To begin with, there was no direct viral measurement that they were concerned about viral transmission of COVID-19; instead, they assessed that aerosol and blood contamination were the risks of viral transmission because they believed that both aerosol and blood contained SARS-CoV-2. Second, most of the research methodology from this review was performed by bacterial and blood contamination measurement. The amount of aerosol produced by oral surgery was not directly measured. They proposed that further studies should use a more advanced and sensitivity methodology.

One of the studies included in Gallagher J E et al. systematic review was from Hallier C et al.[17] in 2010. The objective of this study was to determine the amount of aerosol produced by each dental procedure and compare it to when a commercially available air cleaning system was opened or closed. The methodology used this study was to place the blood agar plate near the operating site, then incubate it aerobically and count the colony forming units (CFU). The average amount of bioaerosols varies by procedure: higher levels were found for cavity preparation (24–105 CFU/m3) and ultrasonic scaling (42–71 CFU/m3), while lower levels were found for extraction (9–66 CFU/m3) and oral examination (24–62 CFU/m3). The use of a commercially available air cleaning system reduced bacterial contamination in all procedures significantly. The last thing they discovered was that the design of clinics was a factor of bacterial contamination, and they believed that multiple chair clinics were greater risk of generated dental aerosol.

In addition, Jimson S et al.[15] discovered that the bacterial density of the air is considerable following minor oral surgical procedures. Similar to Kobza J et al.[16], they discovered that the concentration of bacteria and fungi in the air increased significantly at two dentist offices (a one-chair clinic and a multi- chair clinic) during dental treatment sessions, and gram-positive cocci represent the majority of the organisms in both dental procedures, accounting for 74 to 100 percent of the total.

2.6 Use of air particle counter to measure dental aerosol

In November of 2020, Nulty A et al.[33] conducted a study to measure dental aerosol with and without the use of high-volume extraoral suction. The purpose of this study was to measure aerosol using the concept of particle concentration in the air and compare when opening or closing high-volume extra oral suction. The results of this study differed from those of Gallagher J E et al. in that they measured particle concentrations in the air by air particle counter (an industrial Trotec PC220 particle counter) because this was perform in vitro study that they could not use microbial air contamination methodology. They took measurement while performing each procedure in phantom head models. Besides this, they reported that the air particle counter which uses the light-scattering mechanism, was accurate within 95%, and from the results they discovered that there were significant differences in the amount of aerosol particle between open and close high-volume extraoral suction. They believed that the particle in the aerosol from dental practice was important because more of aerosol increased the risk of transmission of SARS-CoV-2, and this virus has a diameter of 60-140 nanometers[54] which is probably a component of aerosol as classified as PM1, PM2.5, PM10. The limitation of this study was that they did not directly measure the amount of virus and bacteria because the study lacked in vivo effects such as saliva, blood, breathing, patient interaction, and so on as a consequence of performing in phantom head.

As same as Ren Y et al.[55], they studied the effectiveness of aerosol removal from air mechanical ventilation and portable air cleaners with HEPA filters. The methodology of this study was to burn incense in 52 enclosed dental treatment rooms and then measured the amount of aerosol by using a light-scattering air particle counter in the presence of open or closed mechanical ventilation and a portable air cleaner. They measured room air flow and particle concentration of 0.3 micrometers after incense burn because they believed this particle diameter had the greatest potential for penetration, and they discovered that using mechanical ventilation alone will eliminate aerosol particle within 30 minutes. The combination of mechanical ventilation and a portable air cleaner, on the other hand, will completely remove aerosol within 4 to 12 minutes. Moreover, they suggested that a portable air cleaner was an effective thing for a poorly ventilated room, and that both mechanical ventilation and a portable air cleaner were important processes in reducing the amount of aerosol produced by dental procedures. The limitation of this study was their method; instead of dental procedures, they burned incense, and this study was similar to Nulty et al.'s paper, in which they assess aerosol by measuring aerosol concentration because they could not use the microbial air contamination method.

Similar to Matys J et al.[35], they used air particle counter to measure aerosol from many dental procedures such as, caries removal, tooth polishing and ultrasonic scaling. Furthermore, they evaluated which suction system are the most effective to reduce aerosol from dental procedures and they found that the most generated aerosol forming dental procedure is caries removal by used of airotor with used of saliva ejector alone, and surprisingly, ultrasonic scaling generated aerosol in low amount of aerosol.

2.7 Use of microbial air contamination methodology

According to a review article by Pasquarella C et al.[22], they concluded from many studies that it was difficult to count microorganisms in the air. Many different approaches were used, which could be classified into four categories:

1) counting colony forming units per cubic meter of air (CFU/m3)

2) counting CFU on settling plates

3) measuring a chemical component of microbial cells/m3 of air

4) counting under a microscope.

Because such approaches were insufficiently sensitive, measuring chemical components of microbial cells (ATP, DNA, enzymes) had not yet developed practical and trustworthy approaches for studying of airborne microorganisms. Counts performed under the microscope or by automatic counters fluorescence counters (flow cytometry or fluorescent in situ hybridization) had limited applications and were constantly being researched.

The count of CFU was currently the only viable method of measuring airborne microorganisms. The most crucial parameter was the CFU count, which measures the number of potentially proliferating microbial cells. There were two methods for collecting air samples: active air samplers and passive air samplers (the settle plates). Both procedures were very well.

1.Active air sampling

To assess microbial air contamination, count the number of CFU per cubic meter (CFU /m^3) of air. For the analysis, active air samplers that collected a known volume of air blasted into a nutritional medium using various techniques were considered.

2.Passive air sampling

Using settling plates, the procedures were carried out. Petri dishes containing a solid nutrient medium were exposed to the air for a set period of time. Microbes transported by inert particles settle on the nutrient's surface. They established colonies in a number proportional to the degree of microbial contamination in the air after being incubated at 35-37°C for a period of time

A reliable technique of measurement was the critical task to describe microbial contamination. There were four characteristics of the techniques that should be considered

a) caused the least amount of perturbation to the parameter under examination

b) had high repeatability

c) be supported by sufficient proof that what needs to be measured is actually measured

d) be stated in units comprising all quantities required to describe it.

The standard and suggested measures, which were mostly based on CFU /m3 by active air sampling, did not meet the stated standards when applied to microbial surface contamination, whereas measurements taken using settle plates did. As a result, it may be able to develop a science that integrates the measurement of microbial contamination of the air with the potential for microbial contamination of surfaces, using settle plates measurements.

Even so, efforts were made to standardize the passive air sampling method. Regrettably, settle plates were used in a variety of applications. Dishes of varying diameters, exposure times, nutritional medium, and incubation temperatures and times made comparing results acquired by various operators difficult.

Therefore, the Index of Microbial Air contamination (IMA) concept was established in 1978[56] with the purpose of simplifying and standardizing the air sampling method via settle plates. The 1/1/1 strategy was discovered. The IMA classes and maximum permissible IMA values for each at-risk environment were determined experimentally by through a large number of tests in various settings[56, 57].

The procedure for determining the IMA is straightforward. According to the 1/1/1 protocol, a conventional Petri dish 9 cm in diameter containing PCA is kept open to air for 1 hour, 1 meter from the floor and at least 1 meter from any significant physical impediment. The CFU are counted after a 48-hour incubation period at 35-37 °C. The IMA represents the number of CFU.

In 2010, the same researcher who purposed IMA, Pasquarella C et al.[22] conducted a pilot study of microbial environment contamination in dental clinics. The objectives of this study were to analyze of microbial contamination in water, air, and surfaces, in order to develop a standardized method for assessing microbial air and surface contamination. They used both active and passive air sampling, with active sampling using the Surface Air System (SAS) sampler was used to determine the number of microorganisms in the air, and passive sampling to determine the rate at which viable particles settle on surfaces in terms of IMA. In addition, they reported the results in terms of total microbial air contamination, CFU /m3 median values indicated a significant increase (p = 0.003) between microbial air contamination before and during dental procedures, followed by a significant decrease (p = 0.037) once the operating session was completed, and they discussed that active sampling is preferred for determining the risk posed by inhalable aerosols while passive sample is preferred for assessing the risk posed by settled particles on the surfaces.

As same as Manarte-Monteiro P et al.[23], they used the concept of IMA to evaluate air quality in a dental clinic during dental procedures. Besides, the color, shape, size, texture, and hemolytic properties of the colony on the blood agar plates; Gram staining; cell morphology; commercial biochemical assays; and enzyme assays such as catalase, oxidase, coagulase, and DNAse, were used to verify the identity. Despite their inherent limitations, the most numerous bacteria isolated were identified as *Micrococcus sp., Streptococcus sp., and Staphylococcus sp.,* using a commercial biochemical test method.

In 2020, Veronesi L et al.[24] conducted a study comparing active and passive methods in evaluating air contamination in dental clinics and discovered that both active and passive methods were capable of assessing microbial air quality and identifying urgent situations, suggesting that they could both be used for this purpose.

2.8 Location of placing air sampling devices

In the topic of position of placing air sampling devices, Chi-Yu C et al.[58] conducted a study on the spreading characteristics of bacterial aerosol contamination during dental scaling treatment. The purpose of this study was to figure out how bioaerosols spread in four-dimensional (left, right, height, and duration) in a single-chair dental clinic. They used the passive sampling method by placing open-agar plates in 14 different locations that differed in vertical and horizontal distance from the operative field (Figure 5). They discovered that the most bacterial concentration area is at M1, which is 10 centimeters above the patient's oral cavity and 50 centimeters above the floor, follow by the outside of the full cover facial shield, while inside of the facial shield had the least bacterial contamination. These findings demonstrated significance of using a facial shield.

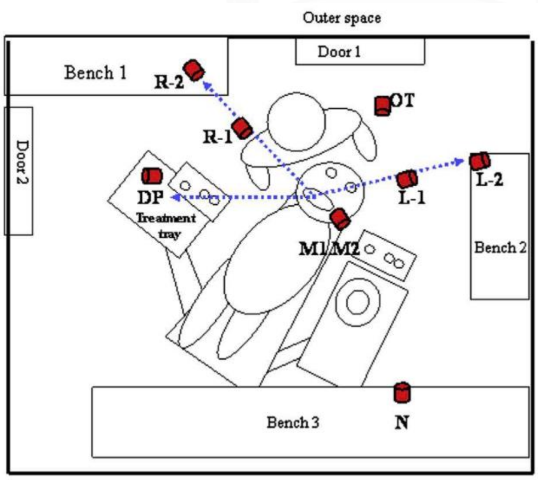

Figure 5. The sampling sites of bacterial aerosols during dental treatment and they discovered that M1 was the most bacterial concentration area

Zemouri C et al.[20] studied dental aerosols in terms of microbial composition and spatial distribution in 2020. They used both active sampling and passive sampling methods and placed the devices at three different locations: 1) on the chest of patient and from oral cavity 30 centimeters 2) closed to dental instruments on the unit and 3) from oral cavity 150 centimeters (Figure 6) and they discovered that the device on the chest and instrumental area had the highest amount of CFU, while the device at 150 centimeters away from oral cavity had no increase bacterial contamination.

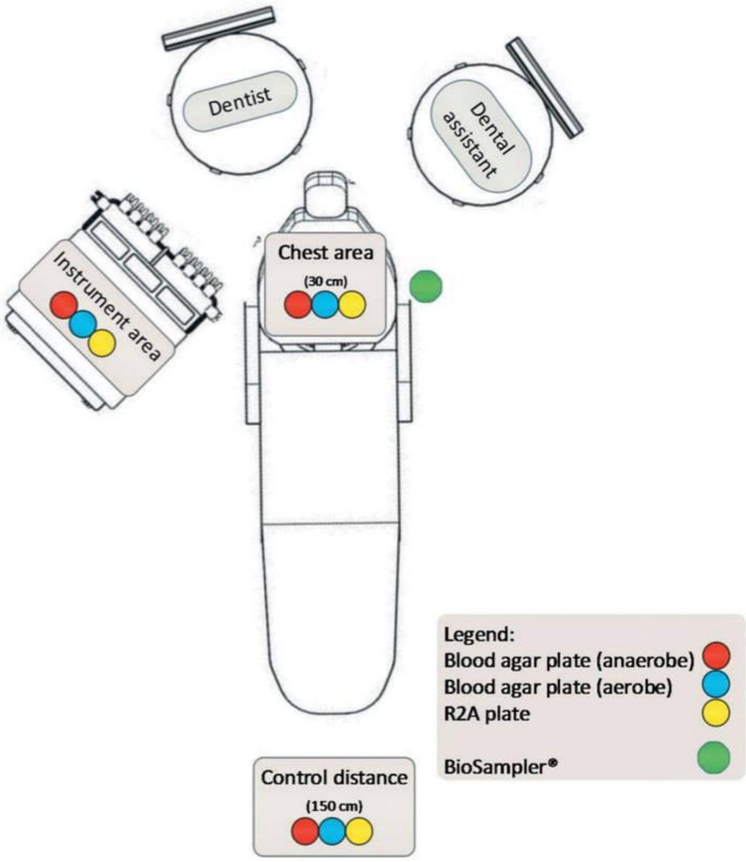

Figure 6. Air sampling devices placement outline from Zemouri C et al.

Chapter III

Materials and methods

3.1 Study population and sample size

3.1.1 Study population: the sample teeth were gathered from patients who had their teeth extracted and voluntarily provided them for this research.

3.1.2 Sample size: the sample size was calculated using the G*Power 3.1 software for Windows, selecting the test comparing more than two means for independent groups(ANOVA), an alpha type error of 0.05, a beta power of 0.85, and effect size of 0.3(calculated from the study of Pasquarella et al.[22]). The test showed a total of 168 samples and compensated for 180 samples (6 groups, 30 samples for each group).

3.1.3 Sample selection

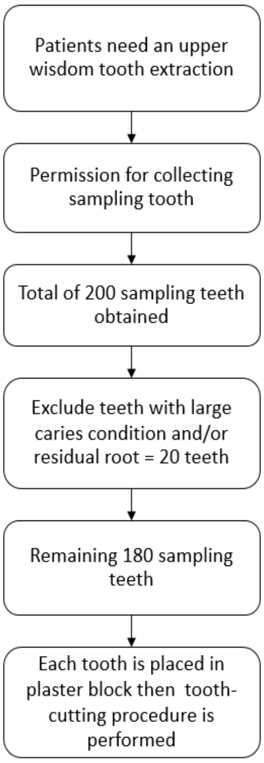

Figure 7. Sampling flow chart of the sampling teeth

3.3 Research protocol

This research was an experimental study that was performed in a closed system to simulate the generation of aerosols during an oral surgery procedure. The three major instruments are as follows: 1. Using a micromotor 2. Using a piezoelectric 3. Using an airotor to perform tooth-cutting procedure.

The air sampler device is the Dust Sensor WIFI Pro by Nanogen (PMS7003W), a light-scattering airborne particle counter. The manufacturer calibrated the sampler using the US HPA standard; as a result, the user does not need to calibrate the air sampler before using it. Moreover, this device was widely used for monitoring air quality in Thailand.

A plastic box with a seal around the size of 1*1*1 M^3 is utilized in the sealed part of the system. Two slots were created to allow the hands and instrument to enter, and the air particle counter was installed as a figure at a distance of 40 centimeters from the cutting tooth point because that was the average working distance between the operator and the operating site[59].

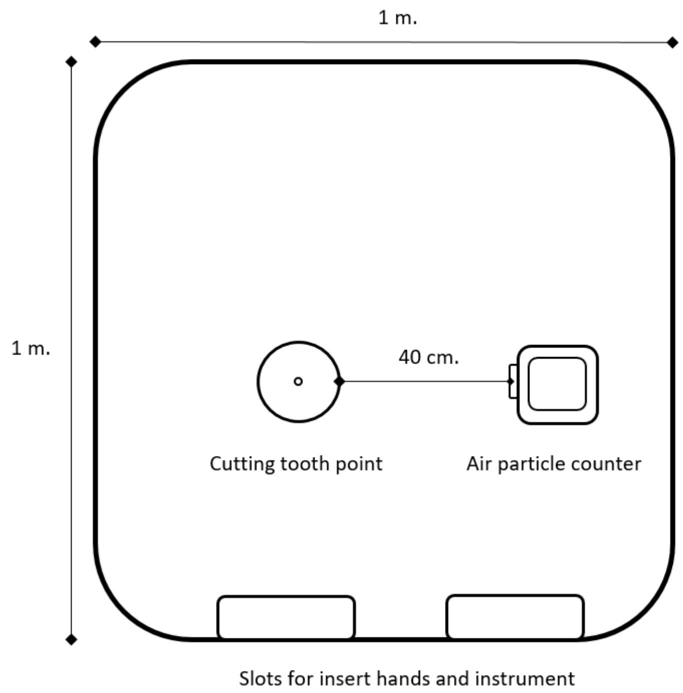

Figure 8. Outline of the experimental system

The procedures of oral surgery are divided into three main types. The micromotor type is used at different speeds. The four speeds are: 1) 20,000 rounds per minute (rpm), 2) 25,000 rpm, 3) 30,000 rpm, and 4) 35,000 rpm. The piezoelectric type used the program D1 (program for cutting teeth or cortex bone), and the last type, the airotor (from NSK S-max M900L), used a rotary speed of 325,000–430,000 rpm. The micromotor and the piezoelectric were connected to the irrigation system at 80 ml/min. The operations of cutting sample human teeth were continued for 1 minute (for enamel 30 seconds and dentine 30 seconds), and after completion of the operation, the system was sealed to measure PM without interfering with the air inside, with the outcome that PM was classified into three parameters, including PM1(particulate matters are smaller than 0.1 micrometers), PM2.5 (particle matters are smaller than 2.5 micrometers), and PM10 (particulate matters are 2.5–10 micrometers) (37). All PM measurements must be less than 10 before each experiment and be used as the experiment's baseline. Results were obtained by comparing which procedure may produce a higher aerosol amount, considering different PM data and baseline PM.

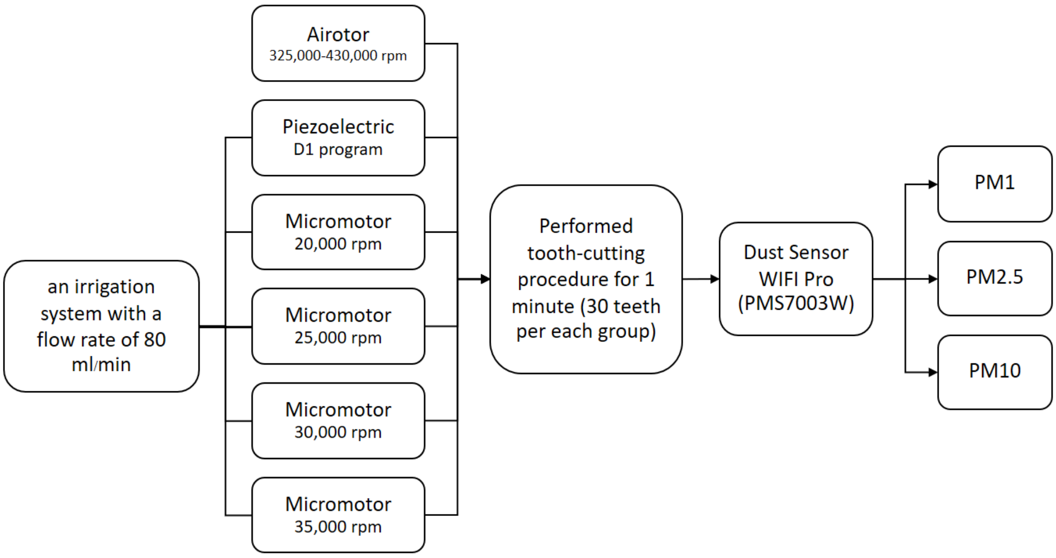

Figure 9. Flow diagram showing the experimental process

3.4 Statistical analysis

The statistical analysis utilized a 95% confidence interval. The one-way ANOVA test was used to compare the differences between each procedure. To assess the significance of variations in times and procedures within each procedure, the one-way repeated ANOVA test was employed. Pairwise comparisons were conducted using the Bonferroni post-hoc test, with a confidence interval set at 95%.

3.5 Ethic approval

This study was approved by ethic committee in human research of the Faculty of Dentistry, Chulalongkorn University (project number HREC-DCU 2022-015, approval number 028/2022).

Chapter IV

Results

The sampling teeth were gathered from a total of 180; all of them were the upper wisdom teeth that were simply extracted from the patients who dedicate their teeth to this research. There are dental caries in some of the teeth, but they are not large caries and they contain one to three sides of complete enamel and dentin. The residual roots of some wisdom teeth were excluded from this study. In all of 180 samples, the teeth were placed in the plaster block to fix their position and locate the position of impacted teeth before they were cut by various instrumental.

From the study, we found that the amount of PM increased in every procedure when performing tooth-cutting, and most increased after beginning tooth-cutting in 80-100 seconds. The increase of PM1, PM2.5, and PM10 in all procedures was found between the starting point and the peak of PM in every procedure. At the starting point, the PM value between each procedure was at the same level. At the peak of the increased PM value, the maximal value was generated using the airotor, followed by the piezoelectric and the group of micromotor, respectively.

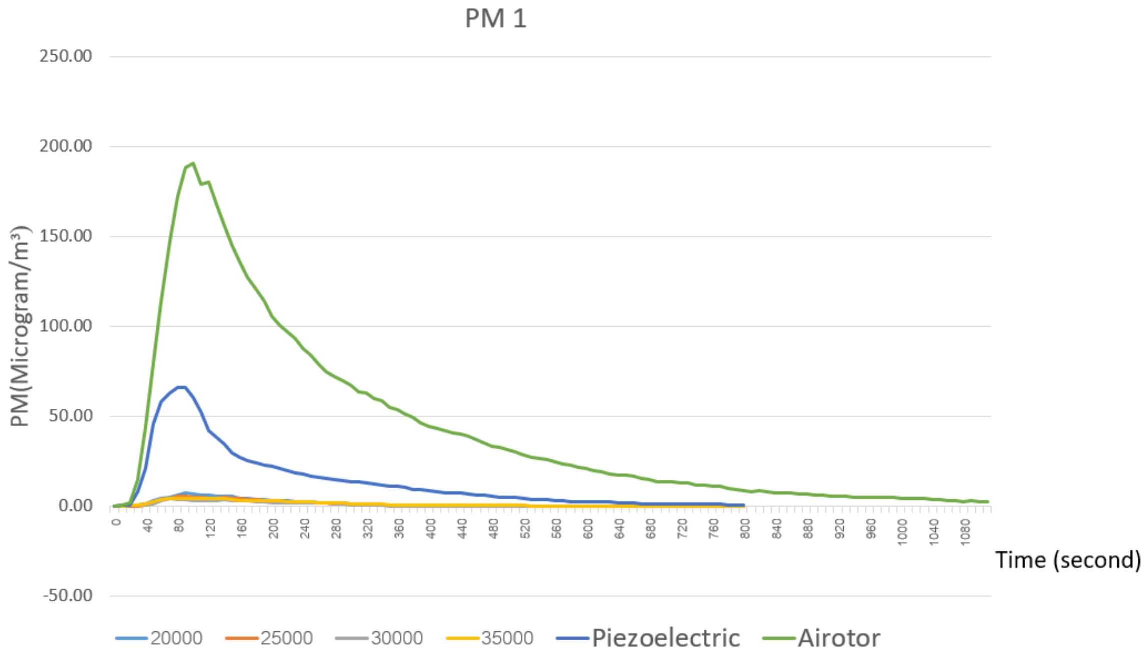

Figure 10. The amount of PM1 in tooth cutting procedure

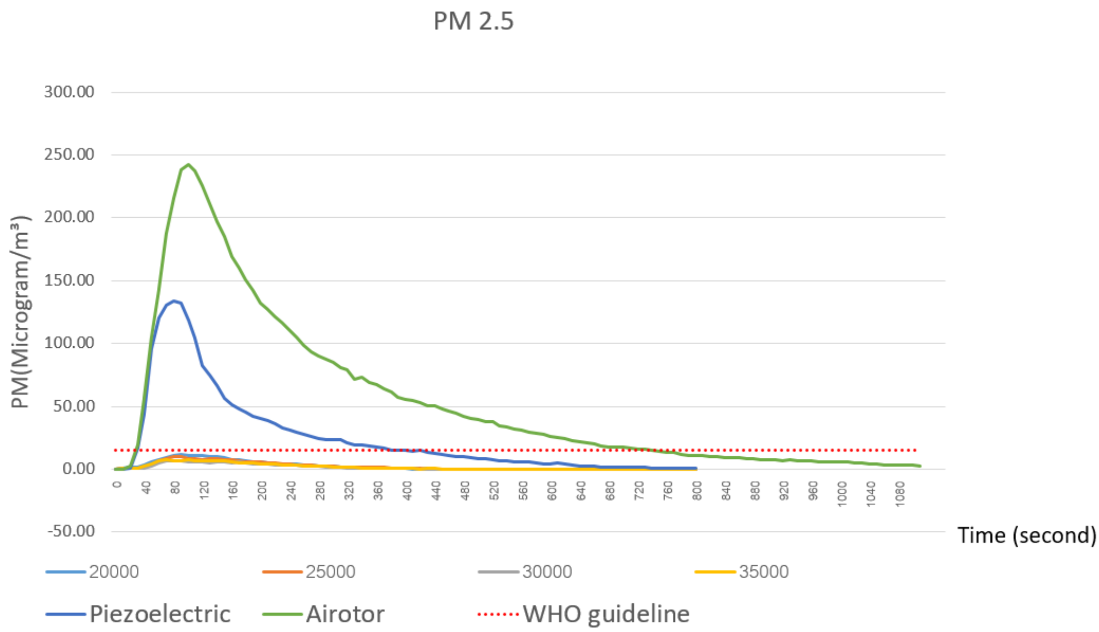

Figure 11. The amount of PM2.5 in tooth cutting procedure

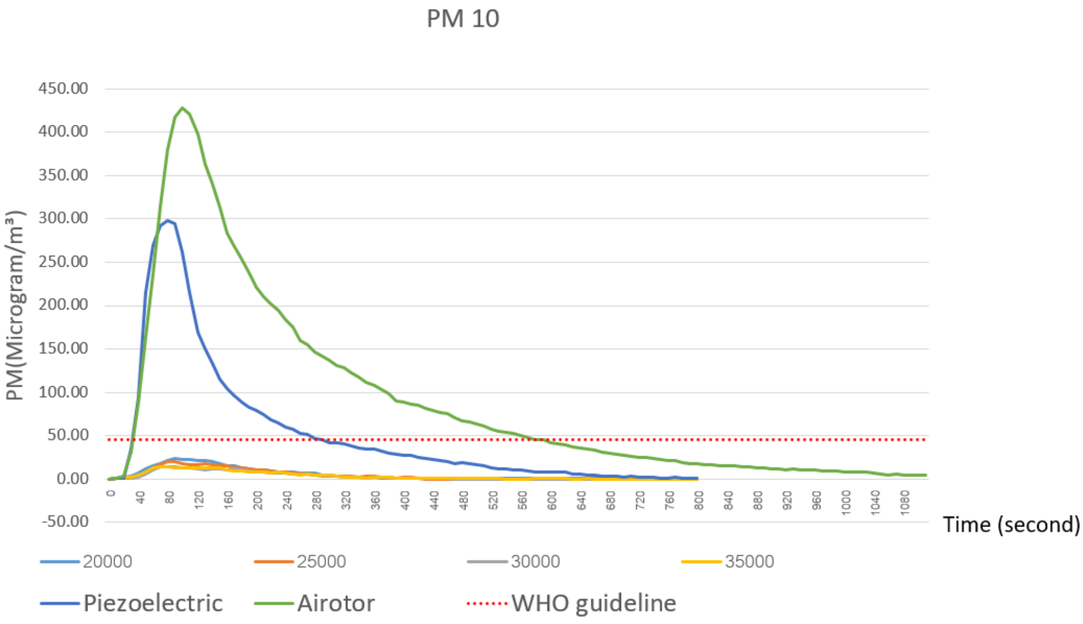

Figure 12. The amount of PM10 in tooth cutting procedure

After the maximum increase in PM, PM decreases as follows: the use of an airotor required an average of around 1000 seconds to return to baseline, compared to the piezoelectric group's average of about 800 seconds and the micromotor group's average of about 500 seconds. In the micromotor group, it was found that the PM generated and the time required to return the amount to the baseline did not differ significantly at speeds of 20000 rpm, 25000 rpm, 30000 rpm, and 35000 rpm.

From figure 10,11, and 12, PM1, PM2.5, and PM10 were increased after tooth cutting in all procedures. PM 10 values increased the most, followed by PM2.5 and PM1, respectively. In every PM parameter, the most amount of PM was generated by using the airotor, followed by the piezoelectric and the group of micromotors, respectively.

Moreover, the time used to return to the PM baseline value was the longest when using the airotor.

Figure 11 and Figure 12 show a comparison of experimental PM concentrations with WHO-recommended air quality PM2.5 and PM10 concentrations. There are the plots of the WHO guidelines for air quality for PM2.5 and PM10; for PM 2.5, the plot was set at 15 micrograms/m^3, and for PM10, the plot was set at 45 micrograms/m^3. The use of the airotor and the piezoelectric for the tooth cutting procedure generated an amount of PM over the value of the air quality guideline from WHO. However, the group's use of the micromotor did not meet the air quality guidelines from the WHO.

Table 1 PM1 value of all procedures at each time point

Procedure	Time-start (10 sec)	Time-after (90 sec)	Time-finish (800 sec)	P-value
Micromotor 20000	0.27 ± 0.87^{A}	7.17 ± 6.99^{aB}	0.23 ± 1.07^{aA}	<0.001
Micromotor 25000	-0.07 ± 1.02^{A}	5.57 ± 5.17^{aB}	0.00 ± 1.53^{aA}	<0.001
Micromotor 30000	0.23 ± 0.86^{A}	3.90 ± 2.98^{aB}	-0.07 ± 1.46^{aA}	<0.001
Micromotor 35000	0.33 ± 1.03^{A}	4.13 ± 2.64^{aB}	0.30 ± 1.21^{aA}	<0.001
Piezoelectric	0.40 ± 1.07^{A}	66.17 ± 43.34^{bB}	0.83 ± 1.88^{aA}	<0.001
Airotor	0.43 ± 1.33^{A}	188.40 ± 52.68^{bC}	8.80 ± 8.74^{bB}	<0.001
P-value	0.792	<0.001	<0.001	

Table 2 PM2.5 value of all procedures at each time point

Procedure	Time-start (10 sec)	Time-after (90 sec)	Time-finish (800 sec)	P-value
Micro motor 20000	0.63 ±1.27^{A}	11.33 ± 10.47^{aB}	0.20 ± 1.00^{aA}	<0.001
Micro motor 25000	0.40 ± 1.52^{A}	9.63 ± 8.26^{aB}	-0.17 ± 0.99^{aA}	<0.001
Micro motor 30000	0.33 ± 1.03^{A}	6.93 ± 5.48^{aB}	-0.03 ± 1.33^{aA}	<0.001
Micro motor 35000	0.57 ± 1.36^{A}	6.93 ± 4.60^{aB}	-0.07 ± 1.48^{aA}	<0.001
Piezoelectric	0.23 ± 1.04^{A}	132.57 ± 91.05^{bB}	0.60 ± 2.71^{aA}	<0.001
Airotor	0.27 ± 1.51^{A}	238.30 ± 69.66^{bC}	11.17 ± 11.29^{bB}	<0.001
P-value	0.672	<0.001	<0.001	

Table 3 PM10 value of all procedures at each time point

Procedure	Time-start (10 sec)	Time-after (90 sec)	Time-finish (800 sec)	P-value
Micromotor 20000	1.40 ± 2.40^{A}	23.20 ± 21.04^{aB}	0.50 ± 3.04^{aA}	<0.001
Micromotor 25000	0.37 ± 2.65^{A}	20.37 ± 16.79^{aB}	-0.53 ± 2.75^{aA}	<0.001
Micromotor 30000	0.83 ± 1.80^{A}	13.73 ± 12.52^{aB}	-0.13 ± 2.70^{aA}	<0.001
Micromotor 35000	1.07 ± 2.46^{A}	12.93 ± 8.33^{aB}	0.17 ± 2.98^{aA}	<0.001
Piezoelectric	0.53 ± 3.22^{A}	294. 20 ± 209.33^{bB}	1.00 ± 5.08^{aA}	<0.001
Airotor	0.37 ± 2.86^{A}	417. 57 ± 138.68^{bC}	17.33 ± 18.19^{bB}	<0.001
P-value	0.245	<0.001	<0.001	

Different small letters indicate significant differences within the same column, analyzed by the one-way ANOVA test followed by pairwise comparisons analysis with Bonferroni correction.

Different capital letters indicate significant differences within the same row, analyzed by the one-way repeated ANOVA test followed by pairwise comparisons analysis with Bonferroni correction. Capital latter: Row Small latter: Column

For example: from table 3, 23.20 ± 21.04^{aB} mean PM10 which was generated from Micromotor 20000 has a in the value, it is statically significant different from Piezoelectric and Airotor (Which have b in their value) and B mean that at 90 seconds, PM10 which was generated from Micromotor 20000 is statically significant different from the start and finish (Which have A in their value).

From tables 1,2, and 3, the PM values of all procedures at the baseline did not show statistically significant difference; however, after using all instruments for 1 minute to cut the teeth, the peaks of all PM values showed statistically significant differences between the starting point and time after (at 90 seconds). The use of airotor is reported to generate the most aerosol from table1, PM1 which was generated from the use of airotor is 188.40 ±52.68, from table 2, PM2.5 which was generated from the use of airotor is 238.30±69.66 and from table 3, PM10 which was generated from the use of airotor is 417.57±138.68, followed by piezoelectric, from table 2, PM1 which was generated from the use of piezoelectric is 66.17±43.34, from table 2, PM2.5 which was generated from the use of piezoelectric is 132.57±91.05 and from table 3, PM10 which was generated from the use of piezoelectric is 294.20±209.33 and followed by a group of micromotors, from table1 and table2, PM1 and PM2.5 which were generated from the use of group of micromotors are not exceed 11.33±10.47 and from table 3, PM10 which was generated from the use of the group of micromotors is not exceed 23.20±21.04.

Moreover, it was found that the use of an airotor had a statistically significant difference at each of the three time points since the PM values of this group did not return to baseline at 800 seconds, but they needed the most of time of all procedures, at least 1,000 seconds, to recover significantly to baseline.

Chapter V

Discussion

It is commonly known that dental procedures result in the formation of aerosols. Nevertheless, there are currently limited studies in oral surgery. The purpose of this study is to measure the amount of aerosol generated by the various instruments used during oral surgery in the procedure of cutting human teeth for 1 minute, and the results of the study showed that for all procedures the most value of PM was at 90 seconds since the start of all procedure and the greatest PM generated due to the use of airotor, PM1, PM2.5 and PM10 are 188.40 ±52.68, 238.30±69.66 and 417.57±138.68 respectively, followed by the use of piezoelectric, PM1,PM2.5 and PM10 are 66.17±43.34, 132.57±91.05 and 294.20±209.33 respectively and the use of a group of micro motors,PM1,PM2.5 and PM10 are not exceed 23.20±21.04 sequentially. Duration until a value is returned to baseline: the use of an airotor will be used most of the time (average time of 1,000 seconds), followed by the use of piezoelectric (average time of 800 seconds) and the use of a group of micromotors (average time of 500 seconds), respectively. As for the group of micromotors, it does not matter whether the speed is utilized. Even though there is not specific description of aerosol standards from dental procedures, which are bioaerosols, comparing them to WHO air quality guidelines for indoor setting shows that both airotor and piezoelectric tooth-cutting tools produced PM2.5 and PM10 levels that were higher that what was recommended.

Moreover, the utilization of an airotor is a mechanism with high rotating speeds of around 0.5 million rpm and the use of water to remove ablated debris, cool internal moving components, and avoid overheating of the dental pulp. In addition, water in the instrument head remains the coolant, resulting in a high-speed flow departing the handset. It is then delivered in the form of a concentrated and fine spray to the burr tip. The contact of the high-speed, fine-mist spray with the speedily spinning burr tip modifies it further[60]. All of these factors influence the generation of aerosols, including PM1, PM2.5, and PM10. While the piezoelectric uses vibration rather than rotation[61], it persists to vibrate at high frequencies, and it generated all of the aerosols in terms of PM1, Pm2.5, and PM10 higher than the micromotor, which is a rotational instrument but rotates at a low speed. The use of an airotor takes the longest in terms of time to return to the baseline PM value because it produces the most PM, then a piezoelectric and a collection of micromotors.

Studies on aerosols have been performed for a long time, even before the COVID-19 pandemic. Past research has mostly concentrated on the process of identifying the pathogen, which is mainly a bacterial species, and some papers have included the distribution of blood stains[12, 15-19, 22, 23]. Besides, both methods are investigated, similarly to how oral surgery is researched[14]. However, as the pandemic COVID-19 virus begins to spread, past studies might not be able to provide an answer, so they have to be modified in the phase that requires directly detecting the virus. For instance, in 2021, Akin H et al. from Turkey focused on the concept of RT PCR and utilizing actual COVID-19-infected patients. The treatment with an ultrasonic scaler in patients with COVID-19 verified by RT-PCR was able to transmit the COVID-19 virus, according to Turkish research, indicating there is actual COVID-19 spreading in the aerosol-generating procedure[26].

As COVID-19 patients cannot be extensively researched, research based on the particle matter principle has been performed because extensive dental treatment is prohibited in the early phases of the pandemic[62], it cannot be performed on individual patients. The research was transformed into an experimental model by investigating dental procedures in a phantom head to simulate aerosol dispersion in a dental clinic or a lab[33, 35, 55].

In 2020, Nulty A. et al. performed a study based on particle matters principle to measure amount of aerosol from dental procedures and they concluded that the particle in the dental practice aerosol was significant since more aerosol increased the probability of SARS-CoV-2 transmission, and this virus has a diameter of 60-140 nanometers[54], which is most likely the aerosol component categorized as PM1, PM2.5, and PM10[33].

Similar to Matys J et al., they utilized an air particle counter to quantify aerosol from common dental procedures such as caries removal, teeth polishing, and ultrasonic scaling and they found that the most aerosol-forming dental procedure is caries removal using an airotor, and, surprisingly, ultrasonic scaling generated so little aerosol[35].

In addition, Barros M. et al. conducted a study and they discovered that utilizing a high-speed handpiece for endodontic coronal access causes the highest aerosol dispersion and contamination[63].

However, there were few investigations in oral surgery[14]. During the COVID-19 pandemic, oral surgery is a treatment that cannot be ignored because this procedure will be related to urgent and emergency treatment[34]. In the past, most of the studies on oral surgery will still focused mostly on studies of bacteria and blood contamination, while studies on treatment mostly on surgical removal of the impacted tooth[14, 15, 25].

Today, the piezoelectric has become a significant role in oral surgery[28, 61] because it has an advantage over other instruments by allows the maxillofacial surgeon to make accurate bone cuts without injuring any soft tissue and reduces the invasiveness of the surgical process[28]. As a result, the researcher intended to investigate aerosol generated from piezoelectric, similar to an airotor. There is a study that uses the high-speed handpiece for tooth-cutting procedure[25] and there have been reports of using one during the tooth extraction procedure in Thailand.

The surgical removal of an impacted tooth is one aspect of oral surgery; the treatment includes flap surgery, osteotomy, tooth-cutting, and suturing. The most aerosol generated may result from tooth-cutting due to the usage of cutting instruments, the majority of which are rotary or ultrasonic vibrations with a combination of irrigated normal saline solution for a cooling system. As a result of this research, it was found that tooth-cutting is one of the procedures for removing impacted teeth. When the device is utilized as a micromotor, the amount of aerosol created is minimal. Moreover, the combination of extra oral suction and an appropriate air management system will decrease the risk of contact with aerosol transmission disease. The average of duration return to the PM baseline value is 8 minutes and 20 seconds. While the utilization of piezoelectric and airotor generate significant amounts of aerosol, including PM1, PM2.5, and PM10, and require more time than the use of micromotor to return to the PM baseline value, proper air control management and a longer waiting time before next patient may be required (16 minutes 40 seconds for the use of airotor and 13 minutes 20 seconds for the use of piezoelectric). Nonetheless, further research on the use of suction devices in oral surgery could be performed in the future. whether it is possible to reduce the amount of aerosol to be suitable and prevent the spread of diseases transmitted through aerosol, or whether additional equipment is required to control the aerosol that occurs.

There is a limitation in this study since the first effort of this study aims to investigate an observational study of oral surgery in actual patients at a dental clinic. However, we were unable to detect particle matter in this environment due to a variety of circumstances, such as suction, air circulation, and air purifier in the dental clinic. This study must be converted to a study model that will be closed in an experimental setting to decrease external factors that may influence the aerosol measurement, such as the air circulation system and the usage of air purifiers, but will utilize human teeth to simulate the patient's objects.

In the past, there were no specific requirements in Thailand indicating that the amount of particle matter generated should not exceed a certain limit. However, the World Health Organization has established recommendations on global air quality guidelines that PM 2.5 should not exceed averaging time for an annual 5 microgram/m^3 and 24-hours 15 microgram/m^3, and PM10 should not exceed averaging time for an annual 15 microgram/m^3 and 24-hours 45 microgram/m^3, which may need to be considered whether it can be applied to the dental clinic[64].

There is already an established policy in place for air management in dental clinics, which has become common, including the use of PPE, air purifiers, UV, or suction devices[43, 65]. The researcher believes that this study will provide significant information regarding the generation of aerosols from different oral surgery procedures to help choose the appropriate instruments to operate, and consider both the planned treatment technique and the aerosol dispersion. Moreover, and most importantly, to prevent the transmission of COVID-19 and other diseases transmitted by aerosol from oral surgical procedures.

Chapter VI

Conclusion

Tooth-cutting and bone-cutting procedures in oral surgery have a significant impact on aerosol generation and infection control. Using a micromotor effectively keeps PM concentrations below WHO guidelines for indoor PM levels, regardless of speed settings. However, further research is needed to establish a suitable PM standard for dental clinics and monitor PM concentrations. Piezoelectric and airotor instruments generate substantially higher levels of PM during tooth-cutting, making it advisable to avoid their use in dental clinics without proper air management, predominantly airotors in oral surgery.

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