Negative Air Pressure Room Effect on Aerosol Distribution Patterns During Dental Procedures Using Ultrasonic Device

Setyabudi[1,2,3], Ida Bagus Narmada[3,4], Dian Agustin Wahjuningrum[2,3*], Ernie Maduratna Setyawati[3,5], Theresia Indah Budhy[6], Dini Setyowati[7], Tamara Yuanita[2,3], Niraj Kinariwala[8], Anuj Bhardwaj[9,10]

1. Doctoral Study Program, Faculty of Dental Medicine, Universitas Airlangga, Indonesia
2. Department of Conservative Dentistry, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia
3. Academic Dental Hospital, Universitas Airlangga, Surabaya, Indonesia
4. Department of Orthodontic, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia
5. Department of Periodontics, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia
6. Department of Oral Pathology and Maxillofacial, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia
7. Department of Public Health, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia
8. Department of Endodontic, School of Dentistry. Karnavati University, Gujarat, India.
9. Adjunct Professor, Department of Conservative Dentistry, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia
10. Department of Conservative Dentistry and Endodontics, College of Dental Sciences, Rau, Indore. M.P.

Abstract

Ultrasonic devices aid dental procedures, producing aerosols when combined with water. Amid the Covid-19 pandemic, dental professionals face high infection risks from these aerosols. The WHO recommends using negative air pressure rooms to control aerosols in dental settings, yet the efficacy remains uncertain due to aerosols' prolonged survival in exposed air. This study aims to elucidate the impact of negative air pressure rooms at RSKGMP Universitas Airlangga on aerosol distribution during dental procedures involving ultrasonic devices. Fluorescein and aquades were used as coolant, and root canal irrigation was conducted on tooth 11.

Results revealed notable disparities in aerosol distribution patterns and quantities between negative and normal air pressure rooms.

This suggests that negative air pressure rooms affect aerosol distribution differently from normal air pressure rooms. Further research is warranted to better understand these effects and optimize aerosol control measures in dental environments.

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Introduction

The World Health Organization first named the corona virus disease that was first discovered in Wuhan as the 2019 novel corona virus (2019-nCoV) caused by the Severe Acute Respiratory Syndrome Corona virus-2 (SARS-CoV-2) in December 20191. The disease Covid-19 has spread rapidly to more than 190 countries and the spread of this disease has had a wide impact both socially and economically. Dentists occupy a very high level of occupational exposure risk while carrying out their profession because the dentist' suctions produce aerosol which are the transmission medium for Covid-192,3. Various efforts are being made around the world to break the chain of spread and to find a cure. Currently, an effective vaccine is being developed against Covid-19 with the aim of obtaining herd immunity. The problem is that achieving herd immunity require long process and time and the long life of antibodies that are formed is still unclear. During this period, health workers are a group at risk of being exposed to the Covid-19 virus while carrying out their profession.

The occupational risk pyramid shows that in the Covid-19 pandemic situation, dentists occupy a very high level of occupational exposure risk because the AGP during dental treatment are a medium of transmission of Covid-19 disease 4. Aerosol-Generating-Procedure (AGP) is any

***Corresponding author:**
Setyabudi.
Department of Conservative Dentistry, Faculty of Dental Medicine, Universitas Airlangga,
St. Mayjend. Prof. Dr. Moestopo No. 47, Surabaya, Indonesia
E-mail: setyabudi@fkg.unair.ac.id

procedure on a patient that can cause unavoidable production of aerosols of various sizes. The UK's National Emerging Respiratory Virus Threats Advisory Group has stated that dental procedures are procedures using device that have the potential to generate aerosols5. For this reason, WHO establishes aerosol control procedures in dental treatment rooms using a negative air pressure room containing air conditioner, exhaust fan, HEPA (High-Efficiency Particle Air) filter, and UV lamp6. However, the effectiveness of the use of negative air pressure rooms on aerosol control is still unclear until now, this is because aerosols easily survive for a relatively long time in exposed air7. Based on the above problems, it is necessary to conduct research to determine the aerosol distribution pattern with the actual clinical environment (mimic) to be able to see the effectiveness of the negative air pressure room.

Materials and methods

This research was conducted in the negative air pressure room and normal air pressure room at RSKGMP Universitas Airlangga. Used cellulose qualitative filter paper as a microfiltration tool from cellulose that can trap aerosol particles in a random matrix. The material used as a coolant for the ultrasonic device is fluorescein in the form of an orange-reddish powder so that the aerosol contained in the cellulose qualitative filter paper can be seen in the image taken to calculate the surface area of the aerosol.

Fluorescein as Water Coolant

The water coolant for the ultrasonic device used is a mixture of 1 g fluorescein sodium (C.I. 45350, Merck, United States) and 1 L distilled water. The mixture of fluoresceinand distilled water was then filtered before being used as a water supply for the dental unit.

Irrigation with Ultrasonic Device

Mannequin phantom head was set on the dental chair in a semi-supine position. Then, a total of 6 PVC pipes with a length of 0,3 meters were placed from the head rest at 12, 2, 4, 6, 8, and 10 o'clock directions. Cellulose qualitative filter papers (Whatman, Cytiva, United States) were placed on the PVC pipe using double-sided tape with a radius of 30 cm. The dental procedure was done with a preparation using a ultrasonic device (Woodpecker) and tip endodontic for 5 minutes in each treatment.

Calculation of Aerosols on Cellulose Qualitative Filter Paper

Cellulose qualitative filter paper was taken using dental tweezers and put into plastic with labels based on position, room conditions, and the number of treatments. Then, the cellulose qualitative filter paper was placed on a black cardboard and irradiated with 2 UV dental curing lights. Images of each cellulose qualitative filter paper were taken using a DSLR camera (Canon EOS M, Canon, Japan) with ISO 400, f/5, 2" settings and a macro lens (Canon EF 100mm f2.8, Canon, Japan) with orange filter. The aerosol surface area on cellulose qualitative filter paper was calculated in square micrometers (μm^2) from digital images which was analyzed using Image-J software.

Data Analysis

Data of the research results in the form of aerosol surface area mean were processed in a statistical test. Kruskal-Wallis test was done to find out the significant differences on each room, the Mann-Whitney test was done to find out the significant difference of the same o'clock directions between both rooms in abnormal condition, and Independent T test was done to find out significant differences between of the same o'clock directions between both rooms in normal condition.

Results

Resarch Results

The aerosol distribution pattern was determined using the aerosol surface area mean, based on the o'clock position in each room.

Table 1 shows the results of calculation of the aerosol surface area mean on cellulose qualitative filter paper. Based on these data, the highest aerosol distribution in the negative air pressure room was in the position of 10 o'clock direction with a surface area of 3.667.271,8 μm^2, followed by 4 o'clock direction with a surface area of 1.019.368 μm^2, 8 o'clock direction with a surface area of 451.751 μm², 12 o'clock direction with a surface area of 236.791,4 μm², 6 o'clock direction with a surface area of 197.056 μm², and the lowestaerosol distribution was at 2 o'clock direction with a surface area of 59.875 μm².

Groups	N	x̄ (μm²)	σ
12 o'clock normal	5	848.857,2	465.824,3
2 o'clock normal	5	114.447	58.953
4 o'clock normal	5	2.330.724	2.231.647
6 o'clock normal	5	825.406,4	429.201,4
8 o'clock normal	5	10.444.576,6	10.297.071,2
10 o'clock normal	5	1.492.766,6	689.237,1
12 o'clock negative	5	236.791,4	155.755,1
2 o'clock negative	5	59.875	14.131,2
4 o'clock negative	5	1.019.368	672.655,8
6 o'clock negative	5	197.056	89.619,9
8 o'clock negative	5	451.751	251.454,6
10 o'clock negative	5	3.667.271,8	3.518.880,8

Table 1. Mean and standard deviation of aerosol surface area on cellulose qualitative filter paper.

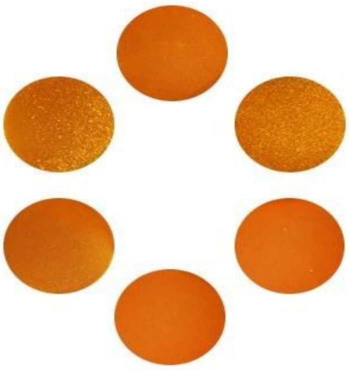

Figure 1. Photograph of cellulose qualitative filter papers with 12, 2, 4, 6, 8, and 10 o'clock directions in the negative air pressure room from the first treatment.

Meanwhile, the highest aerosol distribution in the normal-air-pressure room was at the 8 o'clock direction with a surface area of 10.444.576,6 μm², followed by 4 o'clock direction with a surface area of 2.330.724 μm², 10 o'clock direction with surface area of 1.492.766,6 μm², 12 o'clock direction with a surface area of 848.857,2 μm², 6 o'clock direction with a surface area of 825.406,4 μm², and the lowest aerosol distribution was at 2 o'clock directionwith a surface area of 114.447 μm².

Kruskal Wallis test was done to find out the significant differences between groups in each room. The results of the test can be seen in the table below (Table 2). From Table 2, it can be seen that the value $p > 0.05$ indicates that there was not any significant difference between groups in each room. The Mann-Whitney test was done to find out the significant difference of the same o'clock directions between both rooms in abnormal condition, and Independent T test was done to find out significant differences between of the same o'clock directions between both rooms in normal condition. The results of the test can be seen in the table below (Table 3 & 4). From Table 2, it can be seen that the value $p > 0.05$ indicates that there was not any significant difference between in each groups.

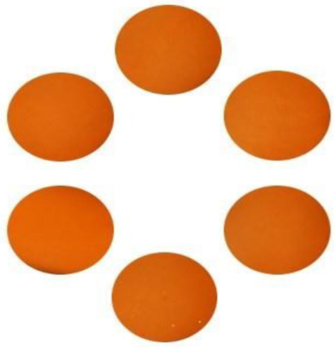

Figure 2. Photograph of cellulose qualitative filter papers with 12, 2, 4, 6, 8, and 10 o'clock directions in the normal air pressure room from the first treatment.

Aerosol	*Kruskal Wallis test*
	P
Negative air pressure room	.652
Normal air pressure room	.347

Table 2. Results of Kruskal-Wallis test to find out the significant differences between groups in eachroom.

Kelompok	**Asymp. Sig**
Jam 12 *negative air pressure room*	.117
Jam 12 *normal air pressure room*	
Jam 4 *negative air pressure room*	.917
Jam 4 *normal air pressure room*	
Jam 8 *negative air pressure room*	.917
Jam 8 *normal air pressure room*	
Jam 10 *negative air pressure room*	.465
Jam 10 *normal air pressure room*	

Table 3. Results of Mann Whitney test to find out the of the same o'clock directions between both rooms in abnormal condition.

Kelompok	Asymp. Sig
Jam 2 *negative air pressure room*	.117
Jam 2 *normal air pressure room*	
Jam 6 *negative air pressure room*	.394
Jam 6 *normal air pressure room*	

Table 4. Results of Independent T-test to find out the of the same o'clock directions between both rooms in normal condition.

Discussion

This research aims to determine and explain the negative air pressure room RSKGMP Universitas Airlangga effect on aerosol distribution patterns during dental root canal irrigation procedures using an irrigation ultrasonic device. The difference in the aerosol distribution pattern and the significant difference in the average aerosol distribution are caused by the presence of a negative air pressure room. In the negative air pressure room working system at the RSKGMP Universitas Airlangga, the negative pressure created in the room will only allow air to exit the room through the ventilation system and there is a filtration process which works continuously by an air conditioner which functions to remove cold air and an exhaust fan which functions to suck in air or aerosols arising from dental root canal irrigation procedures[8,9,10]. The air in the room and coming from the air conditioner will be contaminated with viruses or the spread of aerosols as a result of root canal irrigation and then the air will be expelled through the exhaust fan. The negative air pressure room and the normal air pressure room in this research have self closing doors with windows that are tightly closed, because negative pressure in the room can only be maintained if the doors and windows are completely closed[11], so it can be ascertained that aerosols in both rooms are not affected by airflow from the door or window gaps.

In the negative air pressure room, the exhaust fan is located around the 6 o'clock direction and in this research the exhaust fan was proven to reduce the amount of aerosol distribution which was in accordance with previous studies, there was a 90% reduction in the amount of aerosol distribution at a distance of 0.5 meters due to the use of an exhaust fan[12], while the air conditioner is on the ceiling around 12 o'clock. The working mechanism and the position of the two tools certainly have an influence on the amount and pattern of aerosol distribution. The effect of the air conditioner and exhaust fan looks good, this can be seen from the average aerosol distribution in each clockwise direction in the negative air pressure room which has a significant difference compared to the normal air pressure room.
The average distribution of aerosols in the negative air pressure room is at least clockwise 2. This is because the clockwise direction is 2 next to the air conditioner and results when aerosols arise from dental root canal irrigation procedures, aerosols will not lead to clockwise 2, but immediately moves vertically in the direction of blowing air conditioner. While the direction of the needle 6 is in second place from the least. This is because the 6 clockwise direction is close to the exhaust fan and when aerosols arise from the dental root canal irrigation procedure, the aerosol will be directly sucked into the exhaust fan duct. 12 o'clock clockwise occupies the third position of the least. This is because the 12 o'clock clockwise direction is directly below the air conditioner and causes aerosols arising from the root canal irrigation procedure to move vertically to the floor and pass through the 12 o'clock clockwise direction. At 4 o'clock direction, more visible than the 12, 2, and 6 clockwise direction. This is because the position of the air flow between the air conditioner and the intake exhaust fan through the 4 o'clock hand causes the aerosol to fall in the air flow area or clockwise 4. The highest position is at the 10 and 8 o'clock hands, it because the 10 and 8 o'clock positions are close to the patient's oral cavity or the mannequin.

In this research it was proven that the negative air pressure room was able to reduce the number and provide a different aerosol distribution pattern compared to the normal air pressure room, it can be seen from the average and aerosol distribution pattern in each room. However, the statistical test results show that there is no significant difference between each clockwise direction in the two research rooms. This shows that this research still has several shortcomings, such as the lack of sensitivity of the aerosol measuring device, the lack of sterilization when taking filter paper, and the unknown airflow pattern in the negative air pressure room of the RSKGMP Universitas Airlangga. This is because indoor air flow cannot be standardized, it all depends on the situation, conditions, and is very subjective[13,14]. In addition, this research has several other limitations such as the area of the negative air pressure room of 3x3 m^2 which is relatively smaller than the general dental care room so that it cannot be known the pattern of aerosol distribution with a wider radius, but this research aims to determine the pattern of aerosol distribution in negative air pressure room at RSKGMP with a room area that has been adjusted for educational programs.

Conclusion

In this research, it can be concluded that the amount and pattern of aerosol distribution between the negative air pressure room and the normal air pressure room during dental procedures using ultrasonic devices does not have a difference, so use in both rooms has the same risk.

Declaration of Interest

The authors report no conflict of interest.

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