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Comparison of Dissemination of Aerosol and Splatter during Ultrasonic Scaling using Different Masks: A Pilot Study with Relevance to Respiratory Infection Transmission

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Abstract

Background:

Dentists are routinely exposed to a high amount of micro-organism load due to primarily being responsible for the treatment of the structures if the mouth – which is a well-known source of huge bacterial loads. Also, as COVID-19 recently affected the entire world, masks thus were considered to act as a comprehensive strategy of measures to suppress transmission. However, the relevance of aerosol and respiratory infection control extends beyond COVID-19, as respiratory pathogens including seasonal influenza viruses such as influenza A(H1N1)pdm09, commonly referred to as swine flu, influenza A(H3N2), respiratory syncytial virus (RSV), and other respiratory viruses continue to circulate and may be transmitted through respiratory particles.

Aim:

To compare the dissemination of aerosol and splatter during ultrasonic scaling using different masks.

Method:

In this study we evaluated the dissemination of four masks that is N-95 with respirator, N-95 without respirator, a combination of cloth mask and N-95 without respirator, and normal surgical mask by calculating the surface are of filter paper with the help of a previously marked scale which was divided into one-centimeter squares.

Results:

Best protection was seen to be offered by the combined use of the double masking – N-95 without filter plus cloth mask, followed by N-95 mask alone and then the surgical mask.

Graphical Abstract

Introduction

Close to three years ago, the entire world was confronted with a new challenge - the COVID-19 pandemic. As the spread of virus was via air, this became a focal point of research for the scientific world on the presence and spread of virus via droplets and aerosols. Some research has pronounced facts that imply the virus can spread lengthy distances and stay airborne for numerous hours. It is widely known that the virus may unfold via droplets and likely aerosols. The maximum studied droplets and aerosols are the ones produced throughout clinical techniques, which includes intubation. Whether the

aerosols produced through dental techniques have a huge sufficient viral load to be infectious has but to be proven. At this point, till the infectivity of dental aerosols is proven, they need to be handled as doubtlessly infectious and managed to the best possible extent.[1,2]

Although the COVID-19 pandemic brought unprecedented attention to airborne and aerosol transmission, the concern regarding respiratory pathogens in healthcare environments is not limited to SARS-CoV-2. Respiratory viruses such as influenza A, including influenza A(H1N1)pdm09 and A(H3N2), respiratory syncytial virus (RSV), adenoviruses, rhinoviruses and parainfluenza viruses continue to contribute to respiratory infections. Influenza A(H1N1)pdm09, historically referred to as swine flu, continues to circulate as a seasonal influenza virus. In India, ongoing respiratory virus surveillance includes influenza, SARS-CoV-2 and RSV, demonstrating that respiratory viral transmission remains a continuing public health concern beyond the COVID-19 pandemic.[3,4]

The relevance of respiratory viruses to dentistry is particularly important because several routine dental procedures generate aerosols and splatter. Aerosol-generating procedures may therefore represent a potential route for exposure to respiratory pathogens, particularly in enclosed clinical environments where healthcare personnel and patients are in close proximity. While the infectivity of individual respiratory viruses in dental aerosols may differ, the potential for aerosol and splatter dissemination provides a common infection-control concern.[1,2]

N-95 with filter with respirator was banned and so could not be assessed.

Objective

This study aims to evaluate the dissemination of aerosol and splatter during ultrasonic scaling by comparing different masks, so as to find the safest mask that can be worn.

Methodology

This study is a novel study. The sample size has been calculated by G* Power software version 3.1.9.4. Assuming a large effect size of 0.8, α err = 0.5; power of study is 0.95.

Sample size is 24 (6 samples in each group), 4 groups.

The study was performed on a mannequin fitted with a jaw set, set in reclining position stimulating the dental operatory.

4 masks were chosen - a surgical 3 ply mask, a n95 mask without respirator, a n95 mask with respirator, and double masking - a cloth mask over which a n95 without filter mask will be used (however by the time this study was carried out, there was a ban on N-95 with respirator mask so this could not be assessed).

Each mask represents a group. A filter paper sheet will be placed on the inner surface of the mask to check the dissemination of aerosols. An ultrafiltrate-containing fluorescent dye - fluorescein will be used in the reservoir supplying the scaler unit.

The experimental setup consisted of a dental mannequin positioned on a dental chair, with the ultrasonic scaler used under standardized conditions. The arrangement of the mannequin, operator position, and sampling locations is illustrated in Fig. 1 and materials used are illustrated in Fig. 2.

The dissemination of aerosol was calculated by calculating the surface area of the filter paper with the help of a previously marked scale which was divided into one-centimeter squares. A single dot in the one-centimeter square counts as contaminated and will be counted as one.

Informed consent

to participate was obtained from all of the participants in the study. In each group, 6 participants wore the same mask and performed mock scaling for 45 min. The 45 minutes were divided into 3 intervals of 15 min. After every 15- minute interval, the participant replaced the filter paper. Thus, for each participant there were 3 filter papers - of which a mean was calculated. Thus, each group had 6 means, of which a complete mean was calculated for accuracy. Between each group, comparison was carried out by analysis of variance test

Results

As shown in below Table 1, group's comparison was carried out for all the efficacy of masks material at different time intervals through ANOVA followed by Bonferroni's post hoc turkey's test. The between and within group comparison was calculated with mean difference which was statistically significant ($P < 0.05$).

As shown below in Table 2; subgroup comparison was done. It was observed that a statistically significant difference ($p < 0.05$) was observed among all the masks at different intervals while only a significant difference was observed for cloth + N 95 followed by N 95 alone. This signifies that the better efficacy was observed for cloth + N 95 mask at different intervals followed by N 95. Other masks had more or less equal efficacy with regards to the outcome assessed. Multiple group comparison using ANOVA followed by Bonferroni's post hoc turkey's test showed below in Table 3.

Table 1
Calculation of dissemination on filter paper

Type of mask	Person	1st 15 min interval	2nd 15 min interval	3rd 15 min interval
Cloth + N95 mask	1	0	5	1
	2	0	3	0
	3	0	10	1
	4	0	6	0
	5	0	3	0
	6	1	2	0
Surgical mask	1	21	1	28
	2	1	1	11
	3	5	0	5
	4	13	5	1
	5	1	9	6
	6	8	6	17
N 95 mask	1	0	6	3
	2	0	5	5
	3	1	10	6
	4	1	2	4
	5	0	5	2
	6	2	4	3

Table 2
Comparison of mean differences between and within groups

Between Groups	Sum of Squares	df	Mean Square	F	Sig.
	674.370	**8**	**84.296**	**4.018**	**.001***
Within Groups	944.000	45	20.978		
Total	1618.370	53			

Table 3
showing multiple group comparison using ANOVA followed by bonferroni's post hoc tukeys test

Groups	Mean	Count	Degree of freedom (df)	P value (sig.)
Cloth + N95 at different intervals	1.77	6	5	P < 0.001**
N95 at different intervals	3.27	6	5	P < 0.03*
Surgical at different intervals	7.71	6	5	P < 0.05

Means for groups in homogeneous subsets are displayed.
Uses Harmonic Mean Sample Size = 6.000.

Discussion

During routine dental procedures, potential spread of diseases may be through various means such as contact with various body fluids, contact with infected surfaces contaminated by patient contact as well as through the airborne route by infectious particles of the patient.[4] There is immense historical evidence that showcases spread of infection through the airborne route. This potential route of infection spread was recognized long before the discovery of

specific infectious agents such as bacteria or viruses. The deadliest as well as the most intricately documented example of airborne spread of diseases is the bubonic plague.[5] More recent examples are tuberculosis, measles as well as the recent SARS virus.[1]

The COVID-19 pandemic further highlighted the importance of respiratory aerosols and the role of respiratory protective measures in healthcare settings. However, the concern regarding respiratory pathogens has continued beyond the pandemic. Influenza viruses, particularly influenza A(H1N1)pdm09 and A(H3N2), along with respiratory syncytial virus (RSV) and SARS-CoV-2, remain important respiratory pathogens under ongoing surveillance. WHO currently incorporates influenza, SARS-CoV-2 and RSV into integrated respiratory-virus surveillance, while Indian surveillance systems continue to monitor these major respiratory viruses across community and hospital settings.

The earliest use of aerosol and splatter in dentistry was by Micik et al. who defined aerosol as particles less than 50 micrometers in diameter. It was found that these particles remain airborne for a time before settling on surfaces. Smaller particles of aerosol (0.5 to 10 μm in diameter) are liable to penetrate the lungs and thus have the most potential risk for transmitting infections. Splatter was defined as airborne particles larger than 50 μm in diameter. These particles are however too large to remain suspended in the air and thus they are seen to settle faster.[1]

The most commonly used protection against aerosol contamination is the use of masks. Masks seem to be the most economical and efficient method of mitigating the spread of infections. There are many systematic reviews that have documented the effect of face masks in preventing the spread of infections.[6,7,8] During the COVID pandemic several small-scale studies were carried out. One such study was carried out in 124 Beijing households with at least one person tested positive in the house, and it was found that the use of masks by the remaining members reduced the virus transmission by 79% .[9] Another study was carried out at the community level in Massachusetts Brigham Hospital among healthcare workers. It was found that among the health care workers, following of the universal masking policies led to a significant reduction in the transmission of COVID-19 virus.[10] After extensive research studies regarding masking policies, it was found that mandates regarding face masking led to an extensive reduction of newly reported COVID – 19 virus cases varying from region to region between 15–75% within the first 20 days of introduction. The conclusion was that public community wide masking policies led to a daily growth rate reduction by 47% .[11] While the methods of studies and their results differ, the conclusion is such that community wide masking protocol results in a decreased transmission rate of COVID-19 cases.

Although these studies were primarily conducted in the context of COVID-19, the principle of respiratory protection is applicable to a broader range of respiratory infections. Influenza transmission has historically been associated with respiratory droplets and aerosols, and influenza viruses continue to circulate seasonally. Influenza A(H1N1)pdm09 and A(H3N2), along with influenza B, remain part of routine respiratory-virus surveillance. Similarly, RSV is recognized as an important respiratory pathogen, particularly in young children. The continued circulation and surveillance of these pathogens reinforces the need to consider aerosol and splatter control as a routine component of infection prevention in dental healthcare settings rather than as a measure restricted to a single pandemic.

Different types of masks are available in the market for use – such as the N-95 or the particle filtering respirator which is disposable; the normal commonly used disposable medical procedure mask; and the cloth mask which is neither regulated nor standardized .[12] The N95 masks are designed to protect the wearer from aerosol and are 4 layered, mainly made of pun-bound polypropylene (PP) along with other materials. However, this mask generally requires certification by a standardizing agency. It has a tight seal and a high filtration efficiency (95% for particles larger than 300nm). It electrostatically filters particles and is mainly recommended for healthcare workers. They may be made oil and fluid resistant. The major disadvantage is that it has only a one-time use, is not readily available and is not economical. The normal surgical mask is basically designed to protect the spread of droplets form the wearer instead of protection to the wearer. It is 3 layered, mainly made of melt blown PP. These masks are standardized but there is a wide variety available. These masks are inexpensive, fluid and flame resistant, yet there have not been found to be many differences in infection rate for healthcare workers wearing N95 masks versus surgical masks. The major disadvantage is that they are not fitted and not intended for use in high risk environments.

Cloth masks are made of a wide variety of materials such as cotton, silk, nylon. However, they are not regulated by any standardization body. They may be reused but are not suitable for healthcare use.[13]

The relevance of these findings therefore extends beyond the COVID-19 pandemic. The present study does not establish transmission of a particular respiratory pathogen; rather, it demonstrates the dissemination of aerosol and splatter during ultrasonic scaling and compares the ability of different masks to limit this dissemination. Since dental aerosols may potentially contain microorganisms originating from the oral cavity and respiratory tract, reducing their dissemination may contribute to reducing occupational exposure to a range of infectious agents.

By the time the study was carried out there was a ban on N-95 mask with filter or respirator. This primarily was due to the reason that it was unknown whether the respirator was a one-way valve or a two-way valve. A respirator that is one-way valve that protects the wearer but does not filter out the aerosols released by the wearer. This thus puts those around you at an immense risk of acquiring the disease. Majorly the idea of a face mask is to protect not just the wearer but also those around you from acquiring the illness. This was released after the study was accepted and so in the study the N95 mask with respirators have been omitted form the study.

After carrying out of the study and evaluating the results with the annova test and bonferronis post hoc tukeys test, it has been concluded that that the best efficacy was found with the combined use of double masking – N95 plus cloth mask, followed by N95 mask alone. The other masks had similar efficacy.

In the post-COVID era, these findings may therefore be considered in the broader context of respiratory infection prevention in dental practice. The continued circulation of influenza viruses, RSV and SARS-CoV-2 demonstrates that respiratory infection risks are dynamic and are not confined to a single pandemic event. WHO has consequently moved towards integrated surveillance of influenza, SARS-CoV-2 and RSV, reflecting the need for a broader respiratory-virus preparedness approach.

It is important to emphasize that the present study evaluated aerosol and splatter dissemination rather than the presence or infectivity of respiratory viruses within the aerosol. Further studies incorporating microbiological or viral detection methods could help determine whether the aerosol generated during ultrasonic scaling contains viable respiratory pathogens and whether different mask types provide differential protection against such pathogens. This could provide a basis for translating the present findings into more pathogen-specific infection-control recommendations.

Conclusion

While any mask will give basic protection to the wearer, the study found that the best protection is offered by the combined use of double masking – N95 plus cloth mask, followed by N95 mask alone and then surgical mask. Although the study was conceived during the COVID-19 era, its relevance extends to the continuing challenge of respiratory infections, including seasonal influenza and influenza A(H1N1)pdm09, RSV and other respiratory pathogens. The findings therefore support continued

attention to aerosol and splatter control in dental practice as part of broader respiratory infection-control measures.

Abbreviations

ANOVA	Analysis of Variance
COVID-19	Coronavirus Disease 2019
df	Degrees of Freedom
FDA	Food and Drug Administration
N95 / N-95	N95 Filtering Face piece Respirator
PP	Polypropylene
RSV	Respiratory Syncytial Virus
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
WHO	World Health Organization

Declarations

Ethical approval :

Approved by Ethics Committee meeting at Dr D Y Patil Dental College, Pimpri, Pune- 18. (Ref no.DYPDCH/EC/648/72/2021)

Consent to participate:

Informed consent to participate was obtained from all of the participants in the study

Consent for publication:

Not applicable. This study did not involve human participants or identifiable personal data; the experiments were performed using a dental mannequin.

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Author Contribution

A. Samidha Jambhekar - writer and reviewer of the manuscript

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Availability of data and materials:

The datasets generated and/or analyzed during the current study are available in the main manuscript.

Competing interest: No competing interest

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Figures



Figure 1

Participant performing mock scaling



Figure 2

Materials used for the study

Supplementary Files

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