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Comparative evaluation of Aerosol and Splatter spread during Maxillary and Mandibular anterior teeth preparation: A Pilot Study

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ABSTRACT

The aim of this study was to calculate the amount of aerosol and splatter spread at three distances and directions in maxillary and mandibular arches. The present study was performed on a dental manikin in a dental stimulation laboratory. The manikin was set to a reclined position for maxillary arch and to a straight position for mandibular arch to stimulate the clinical operatory position of the patient for dental restorative procedures. Cotton cellulose filter paper was placed in three different directions from the center of mouth of dental manikin at 2, 10 and 12 o' clock positions and at 20, 40 and 60 inches distance. One gram of ultra- filtrate containing fluorescent dye was mixed with one liter of water and filtered. The mixture was filled in a reservoir bottle attached to the dental manikin. Crown preparation was done by the principal investigator in a specific time of 3 min on tooth #11 using a two-hole hand piece. Immediately after the crown preparation, the first set of filter papers were replaced by new ones in all positions and distances. The second set of filter papers was removed after 30 mins. The same procedure was repeated on tooth #41 using a two-hole hand piece. The splatter and aerosol contaminated area on the filter papers were calculated by using woods lamp.The concentration of aerosol and splatter decreases with the increase in time frame and distances. The amount of aerosol and splatter differs in the maxillary and mandibular arch. The present study confirms the zone around the chair that needs to be disinfected critically and the amount of time required for chair isolation between two appointments after the use of airotor in any dental procedure.

Keywords: *Aerosol, Splatter, Cellulose Filter Paper, Fluorescent Dye, Woods Lamp*

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INTRODUCTION

In the light of the SARS-CoV-2 pandemic, dentistry has been classified as one of the very high-risk occupations for transmission of the disease because of aerosols produced [1]. Dental turbines and scalers, used every day in dental operatories, feature built-in water spray that generates considerable amounts of water aerosol and splatter [2]. Aerosol is defined as very tiny particles of less than 50 micrometers in diameter and has a potential ability to remain suspended in the air for a considerable time until they settle on the environmental surface or enter the respiratory tract. On the other hand, splatters are large particles of more than 50 micrometers in diameter and are believed to stay in the air for a short time due to its size. Several diseases such as tuberculosis, measles, severe acute respiratory syndrome and herpetic viral infection have been reported to be transmitted through the airborne route. Studies have shown concern that the highly contaminated breathing zone in a dental practice could be the reason for the increased prevalence of the respiratory disease among dentists [3]. The main source of aerosol production in the

dental setting is the water spray of dentalturbines and ultrasonic scalers. The particles in the spray spread either directly from the nozzleor reflected from various surfaces, including the patient's intraoral hard and soft tissues. It is expected that different kinds of dental treatment are associated with different patterns of aerosol production, depending on the instrument used and way it is used [2]. Dentists and dental assistants usually operate at a distance of about 23 inches or less from a patient's oral cavity, the transmission of SARS-CoV-2 aerosols is suggested in addition to transmission via droplets. Other studies using culture methods have shown aerosol generating procedures produce a 15-30-fold increase in the number of colony- forming units cultivable from the air compared with pre-procedural levels and can extend 1 to 4 feet from the field of operation [4]. Recently, fear and anxiety among dentists prevailed during the COVID-19 pandemic [3]. Several studies have reported that dentists around the globe are reluctant to perform routine dental procedures due to psychological distress, lack of coordination between health care services, the emergence of new variants of COVID-19 and fear of acquiring and transmitting the infection to their family. The paucity of strong clinical evidence on aerosol and splatter contamination distance, duration may be a barrier for the implementation of quality dentalservices which in turn are likely to influence the quality of care provided to patients [3]. Considering the aforementioned rationale, the current study will be conducted to evaluate amount of contamination due to aerosol and splatter produced in the maxillary andthe mandibular arch based on the distance, direction and time. The aim of this study was to calculate the amount of aerosol and splatter spread at three distances and directions in maxillary and mandibular arches so that the dental personnel can weigh the applied risk and take due precautions against the same. Objectives were; A) To evaluate and compare the amount of aerosol and splatter spread at 20, 40 and 60 inches distance, B) To evaluate and compare the amount of aerosol and splatter spread in 10,12,2 o' clock directions, C) To evaluate and compare the amount of aerosol and splatter spread between two-time frames (F1= 0-15 mins and F2= 15-30 mins) after the procedure.

MATERIAL AND METHODS

The study was performed on a dental manikin in a dental simulation laboratory where the amount of aerosol and splatter produced will be examined. The manikin was set at a reclined position for maxillary arch and at a straight position for mandibular arch to simulate theclinical operatory position of the patient for dental restorative procedures. Cotton cellulose filter papers was placed in three different directions from the center of the mouth of dental manikin at 2,10,12 o' clock positions and at 20,40,60 inches distance. One gram of ultra- filtrate containing fluorescent dye was mixed with one liter of water and filtered. The mixture was filled in a reservoir bottle attached to the dental manikin. For example, if we wanted to show the cellulose filter paper which is used to count the splatterand aerosol in the first-time frame in the maxillary arch at 2 o' clock position at 40 inches distance, it was denoted as **(F1 Max 2o' D2).** Crown preparation was done by the principal investigator in a specific time of 3 min on tooth #11 using a two-hole handpiece (NSK PANA MAX, speed-3000 rpm). Immediately after thecrown preparation, the first set of filter papers were replaced by new ones in all positions anddistances. The second set of filter papers was removed after 30 mins. After this, Crown preparation was done by the principal investigator in a specific time of 3 min on tooth #41 using a two-hole handpiece (NSK PANA MAX, speed-3000 rpm). Immediately after the crown preparation, the first set of filter papers were replaced by new ones in all positions and distances. The second set of filter papers was removed after 30 mins. The splatter and aerosol contaminated area on the filter papers will calculated by using transparent grids containing a 1 cm^2 box. Each filter paper will cover 184 boxes maximum. Even a small amount in a square box will be taken as a positive finding. The splatter and aerosol contaminated area on the filter papers of maxillary and mandibular arch will be calculated by using woods lamp. Blinding of the filter paper using a Non-Transparent Adhesive Tape was placed across the denotation of filter paper so that the evaluator won't be unbiased to evaluate the filter paper.Contaminated area on the filter papers of maxillary and mandibular arch will be calculated byusing woods lamp.

Table 1: Denotations to the parameters

Parameters	Denotations
Time-	**3 minutes** working airotor
Time Frames-	**F1**= 0-15 mins
	F2= 15-30 mins
Areas To Work Upon-	Maxillary (**Max**)
	Mandibular (**Mand**)
Directions-	**2 o'**clock
	10 o'clock
	12 o'clock
Distances-	**D1**= 20 Inches
	D2= 40 inches
	D3= 60 inches

Figure 1: Distribution of filter papers around the dental manikin at different positions and distances

Figure 2: Distribution of filter papers in operatory during preparation of maxillary central incisor

Figure 3: Dispersion of the ultra-filtratecontaining the fluorescent dye

Figure 4: Crown preparation being done on tooth 11

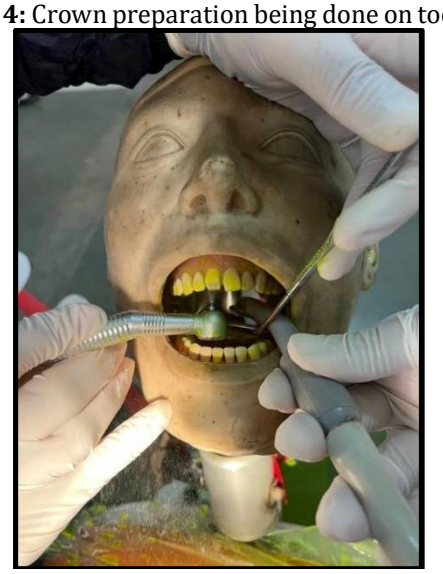
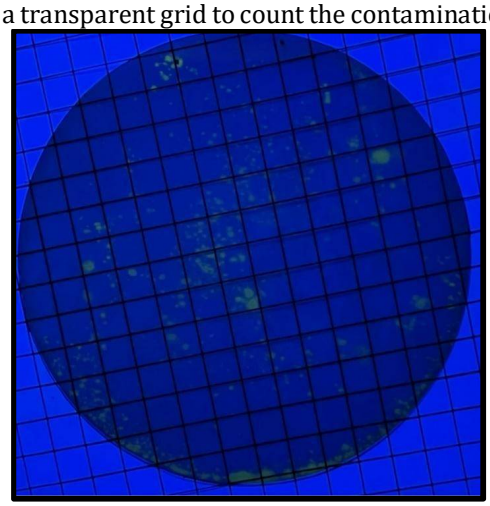


Figure 5: Filter paper disc with a transparent grid to count the contamination area using woods lamp



Statistical Analysis

Data were analyzed using SPSS version 23.0. Mean and standard deviation was calculated for aerosol and splatter produced during crown preparation at different positions and distances. An independent t-test was used to compare differences in the aerosol and splatter produced in different directions and distances in maxillary and mandibular arches. Differences in the amount of splatter produced immediately after crown preparation and 30 min after crown preparation were assessed using an unpaired t-test. A p-value ≤ 0.05 wasconsidered statistically significant.

RESULTS

Immediately after the crown preparation (F1), in the maxillary arch, the maximum amount of splatter of 164 cm^2 was recorded at the 2 o' clock position at a distance of 20 inches (D1). Whereas, the minimum amount of splatter of 4 cm^2 were recorded at the 12 o' clock position ata distance of 60 inches (D3). The amount of splatter decreased with an increase in distance andwas lowest at 60 inches distance away from the patient. Most splatters were produced at the 2o' clock position followed by 12 o' clock and the least at 10 o' clock position. (Table 2). After 30 mins of crown preparation (F2), in the maxillary arch, there overall mean values were less in F2 as compared to that of F1. The maximum splatters of 77 cm2 were recorded at 2 o' clock position at a distance of 20 inches (D2). The least amount of splatter was recorded at 12 o' clock position. (Table 2) Comparing the amount of aerosol produced in the maxillary and mandibular arch, significant differences were noted in F1 group at D1, D2 and D3 at 10 o' clock; D1 and D2 at 12 o' clock and D2 and D3 at 2 o' clock (Table 4). In F2 group, D1 showed significant differences at 12, 10 and 2 o' clock respectively (Table 5). This concludes that, F2 group better than F1 group with respect to both maxillary and mandibular arches. Moreover, D1, D2 and D3 showed good favorable results at 10 o clock as compared to 12 and 2 o' clock; when compared between maxillary and mandibular arch. Now, in the

mandibular arch, immediately after cavity preparation (F1) the maximum amount of 161 cm^2 were recorded at 2 o' clock position at a distance of 20 inches (D1). Most splatters were produced at the 2 o' clock position followed by 12 o' clock and the least at 10 o' clock position. In the same way as maxillary arch, the splatter produced after 30 mins of crown preparation (F2) was less compared to F1 and the least amount of splatter was at 60 inches distance. (Table 3)

Table 2: Distribution of aerosol and splatter in maxillary arch at different positions and distances with sample size

		N	Minimum	Maximum	Mean	Std. Deviation
F1	**10 clock D1**	5	36.00	90.00	74.8000	22.02726
	10 clock D2	5	22.00	26.00	23.2000	1.78885
	10 clock D3	5	4.00	12.00	8.8000	3.03315
	12 clock D1	5	148.00	151.00	149.600	1.14018
	12 clock D2	5	52.00	60.00	56.8000	3.63318
	12 clock D3	5	.00	4.00	1.6000	1.51658
	2 clock D1	5	145.00	164.00	155.600	8.50294
	2 clock D2	5	54.00	60.00	57.6000	2.50998
	2 clock D3	5	18.00	22.00	20.4000	1.81659
F2	**10 clock D1**	5	27.00	32.00	29.8000	1.92354
	10 clock D2	5	2.00	10.00	5.0000	3.16228
	10 clock D3	5	.00	2.00	.8000	1.14018
	12 clock D1	5	14.00	16.00	15.4000	.83666
	12 clock D2	5	2.00	8.00	4.2000	2.28035
	12 clock D3	5	.00	3.00	1.6000	.89443
	2 clock D1	5	60.00	77.00	68.2000	6.18061
	2 clock D2	5	20.00	30.00	25.6000	3.84708
	2 clock D3	5	4.00	12.00	7.0000	3.16228

Table 3: Distribution of aerosol and splatter in mandibular arch at different positions and distances with sample size

		N	Minimum	Maximum	Mean	Std. Deviation
F1	**10 clock D1**	5	38.00	45.00	41.8000	2.86356
	10 clock D2	5	28.00	36.00	30.6000	3.20936
	10 clock D3	5	.00	2.00	.6000	.89443
	12 clock D1	5	54.00	68.00	59.2000	5.40370
	12 clock D2	5	28.00	42.00	33.0000	5.91608
	12 clock D3	5	.00	2.00	.8000	.83666
	2 clock D1	5	131.00	161.00	150.800	12.07063
	2 clock D2	5	120.00	132.00	128.400	4.82701
	2 clock D3	5	24.00	38.00	29.0000	5.47723
F2	**10 clock D1**	5	37.00	43.00	40.4000	2.40832
	10 clock D2	5	.00	4.00	2.0000	1.58114
	10 clock D3	5	.00	1.00	.2000	.44721
	12 clock D1	5	42.00	50.00	45.6000	3.36155
	12 clock D2	5	15.00	22.00	18.4000	3.04959
	12 clock D3	5	.00	4.00	2.0000	.83666
	2 clock D1	5	56.00	65.00	60.2000	3.27109
	2 clock D2	5	19.00	27.00	22.6000	3.64692
	2 clock D3	5	7.00	14.00	9.4000	2.79285

Table 4: Comparison of amount of splatter produced in the maxillary and mandibular arch at time F1.

Maxillary vs Mandibular comparison (F1)	t	df	Mean Difference	P value
F1 10 clock D1	3.322	8	33.00000	.011*
F1 10 clock D2	-4.503	8	-7.40000	.002*
F1 10 clock D3	5.798	8	8.20000	.000*
F1 12 clock D1	36.602	8	90.40000	.000*
F1 12 clock D2	7.665	8	23.80000	.000*
F1 12 clock D3	1.033	8	.80000	.332
F1 2 clock D1	.727	8	4.80000	.488
F1 2 clock D2	-29.099	8	-70.80000	.000*
F1 2 clock D3	-3.332	8	-8.60000	.010*

Table 5: Comparison of amount of splatter produced in the maxillary and mandibular arch at time F1.

Maxillary vsMandibular comparison (F2)	t	df	Mean Difference	P value
F2 10 clock D1	-7.690	8	-10.60000	.000*
F2 10 clock D2	1.897	8	3.00000	.094
F2 10 clock D3	1.265	8	.80000	.242
F2 12 clock D1	-19.413	8	-30.20000	.000*
F2 12 clock D2	-8.339	8	-14.20000	0.08
F2 12 clock D3	1.414	8	.60000	.195
F2 2 clock D1	2.558	8	8.00000	.034*
F2 2 clock D2	1.265	8	3.00000	.241
F2 2 clock D3	-1.272	8	-2.40000	.239

DISCUSSION

In spite of rigorous barrier techniques, dental personnel may be exposed to significant spatter and aerosol dissemination[5]. Any dental procedure results in some amount of mucosal damage, which is practically unavoidable. Hence, it is very important to treat every patient as a potentially infective patient in our everyday practice. This study was conducted to compare the amount of aerosol and duration of aerosol and splatter produced during crown preparation in the maxillary and the mandibular arch at different positions and distances. The result of the study showed significant difference in the mean amount of splatter in maxillary and mandibular arches F1 group at D1, D2 and D3 at 10 o'clock; D1 and D2 at 12 o' clock and D2 and D3 at 2 o' clock. In F2 group, D1 showed significant differences at 12, 10 and 2 o' clock respectively. Also, in our study, maximum aerosol contamination was found in the assistant zone followed by the operator's zone. Veena HR [6] reported the same result where more aerosol and splatter production were found in the assistant zone. It has been noticed that the whole circumference around the manikin showed splatter contamination which decreased with increase in distance. Bennet et al [6] reported that aerosol remains in the practice for around 10 to 30 min following scaling. This finding confirms to our study in which the amount of aerosol was found mostly at a distance of 20 inches after 30 min and almost no aerosol at farther distances, although a significant reduction was noticed after 30 min compared to the time of immediate crown preparation. Therefore, to reduce the risk of contamination from airborne pathogens, especially in this era of the COVID-19 pandemic, it is recommended that practitioners should keep an interval of about 30 mins between two appointments where the first appointment involves use of aerosol producing equipment's and the practitioner should keep wearing their personal protective barriers after the completion of the procedure for 30 mins. Considering the findings of the current study, aerosol and splatter can spread up to 40 inches; therefore, it is desirable to make an arbitrary "red zone" around the dental unit. This red zone will require thorough cleaning and disinfection by antiviral or antimicrobial disinfectant after every patient. No one should be allowed to enter the red zone during the procedure, except for the dentist and the assistant [3]. Also, it is recommended that the operator should notremove the protective barrier immediately after the procedure to reduce the risk of contact with airborne contaminants [7]. Cost-effective methods such as the use of a high-volume evacuator with a large bore evacuator tip should be advocated during crown preparation procedures. Bacteria in the mouth and respiratory tract are dislodged during dental procedures and become aerosol contaminants that may cause infections such as pulmonary TB, pneumonia, andinfluenza. In addition, M. tuberculosis can be aerosolized by coughing, sneezing or even speaking, and the mouth can be contaminated with TB organisms from respiratory secretions [5]. Recently, COVID-19 infection had

received great attention due to the easy transmission throughthe respiratory route. Ahmed et al. reported fear and anxiety among dentists from different countries of acquiring COVID-19 infection during practice and unintentionally causing harm to their families [3]. In general, the dental operatory should be seen as an operation theatre rather than an officeto minimize the risk of cross infection [7].

CONCLUSIONS

Our study demonstrated that quantitative aerosol and splatter produced during crown preparation in maxillary and mandibular arch. The aerosol and splatter in our study was more produced in the 2 o' clock position, thus this makes the assistant more prone to infections suchas tuberculosis, measles, severe acute respiratory syndrome and herpetic viral infection. The spread of aerosol was till 40 inches distance from the dental maniken which creates a red zone around the dental chair that needs to be disinfected carefully. Also, this pilot study shows that the amount of aerosol was mostly observed at a distance of 20 inches after 30 mins and almostno aerosol at further distances. Thus, the practitioners should keep an interval of about 30 minsbetween two appointments. Therefore, it is advisable to use simple, inexpensive precautions such as adequate ventilation in the operatory, face masks and protective eye wear, use of high-volume evacuator and personal barrier techniques such as disposable gloves. Additionally, the operator should not remove the protective barrier immediately after the procedure to reduce the risk of contactwith airborne contaminants.

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