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ORIGINAL RESEARCH

ASSESSMENT OF EFFICACY OF UV LIGHT BASED NOVEL AIR SANITIZING DEVICE IN THE REDUCTION OF ORAL MICROFLORA DURING ORTHODONTIC PROCEDURES

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ABSTRACT

Purpose: Due to the possibility of airborne contamination by biological diseases, implementing severe bio-safety standards inside dental clinic settings has become a primary requirement. Given the potential biological risk of cross-contamination from saliva, blood, aerosol, and/or droplets created during dental treatments, evaluating the qualitative and quantitative reduction of oral microbiota in the presence of UV radiation is critical. This study aims to assess the efficacy of UV tunnel in a qualitative and quantitative reduction in oral microflora during aerosol (debonding) and non-aerosol (bonding) generating orthodontic procedures in a dental clinical setup.

Materials and Methods: The microbial load in the dental clinic's air was measured using the settling plate technique. Petri dishes were standardized and placed throughout the room at various heights and distances. The bacterial/viral load was determined qualitatively and quantitatively using petri dish samples.

Results: Total Viable Count (TVC) was assessed at different time intervals, and except for 24 and 48 hours, it was statistically significant. Total Mold Count (TMC) was assessed at different levels from the patient's oral cavity, and a significant difference was seen between the patient level, the doctor, and the assistant level, even after 48 hours. However, there was no statistical difference at the doctor and patient level in debonding and bonding generating groups.

Conclusion: UV tunnel devices show a statistically significant decline amongst the viable molds but also refrain from chances of recontamination.

1. INTRODUCTION

Dentists are among the most exposed health care professionals, being exposed to a wide variety of aerosols generated during dental procedures. Reduced microbial contamination is an important feature of infection control strategies. The rate of hospital-acquired infections has increased dramatically in the past few years owing to multi-drug resistant strains of certain micro-organisms[1,2].

Harrel and Molinari et al. reported aerosols are composed of a variety of components viz, saliva, nasopharyngeal secretions, blood, dental plaque, tooth scrapping, water from dental unit water pipelines, and other dental materials used during the procedure. Aerosols almost reach a distance of 1.5 m from the patient's oral cavity, at the breathing level of the operating dentist, adjacent surfaces, facial masks, and

face shields[3]. Aerosols and splatter are two common ways for contaminated particles to spread during dental operations. They differ primarily in droplet size, diffusion capacity in the air, and ability to survive in external environmental conditions prior to reaching a host. Aerosols are less than 50 µm in diameter and freely suspended in the air for extended periods; smaller size and lightweight aid them to easily penetrate lungs, further presenting a potential risk for respiratory infections[4,5].

Sterilization with UV radiation is an excellent method of bio-decontamination. Recent research has shown a significant reduction in qualitative and quantitative assessments of oral microbiota when UV radiation is used. The effect of UV irradiation varies depending on characteristics such as organic load, nature of the oral pathogen, intensity, dose, distance from the device, exposure period, direct line of sight from the device or shaded exposure, lamp placement, room size and shape, and surface to be irradiated. Newer touchless sterilization approaches provide an incremental benefit over manual practices by limiting cross-transmission of oral pathogens via environmental surfaces, though literature evidence of the invention of certain pathogens still remains limited[6,7].

Hence, the present pilot study was envisaged with a view to assessing the efficacy of UV tunnel in a qualitative and quantitative reduction in oral microflora during aerosol (debonding) and non-aerosol (bonding) generating orthodontic procedures in a dental clinical setup.

2. MATERIAL AND METHODS

This pilot study was conducted to assess the feasibility of an in-vitro study, which will be conducted in the future. The sample size was calculated with 10% of the original sample and with a total of 16 samples.

Selection criteria:

Inclusion criteria for orthodontic procedures –

1. Aerosol generating procedures – Debonding procedures
2. Non-aerosol generating procedures – Bonding procedures

Exclusion criteria for orthodontic procedures –

1. Patients with systemic illness or conditions
2. Patients with acute or chronic respiratory symptoms or conditions
3. Patients with a history of illness in the last 30 days
4. Any other aerosol-generating or non-aerosol-generating orthodontic procedure

Air sampling

The microbial load in the air of the dental clinic was measured using the settled plate technique. The 90 mm diameter Petri dishes containing either blood agar (Colombia blood agar base (Hach, Loveland, USA), supplemented with 5% sheep blood) or R2A agar (Hach) were exposed to the air for 30 minutes at 80 cm height from the floor. The air was then sampled at six moments during a normal day of patient treatment: 1) before the first procedure. The room was unoccupied for at least 24 hours; 2) 15 minutes during the dental procedure; and 3) 30 minutes after the final treatment (the room was unoccupied during that time). 4) 1 hour after the final procedure (the room was unoccupied during that time). 5) 6 hours after the final procedure (the room was unoccupied during that time). 6) 24 hours after the final procedure (the room was unoccupied during that time). 7) 48 hours after the final procedure (the room was unoccupied during that time). The plates were placed in four locations: 1) on the patient's chest, at doctor's levels; 2) at the level of the nostrils of the treating dentist; 3) at the level of the nostrils of the chairside assistant; 4) at the level of the nostrils of the attendant.

UV Tunnel

The UV tunnel device was 8 8-watt Philips/Osram tube having a fan air volume of 2940 LPM and a fan life of about 50,000 hours. The fan had high speed and high volume with a wavelength of 253.6 nm. The tube life is about 9000 hours, and the AC voltage is about 240V AC. The UV tunnel was kept in the operatory room and the bacterial/viral load was assessed qualitatively and quantitatively using the petri dishes samples.

Methodology

A single-chair operatory was chosen in a dental clinic setup, and x number of sites were selected. While choosing the sites, it would be ensured that there is sufficient and proper distribution of plates at various locations both vertically as well as horizontally, i.e., some Petri dishes were spread around the room at different heights and varying distances and were standardized.

Step 1: There was assessment of the room prior to sanitization. This was carried out to assess the resting baseline of the room.

Step 2: Complete sanitization of the room was carried out with either fumigation, UV lights, or certain disinfectant sprays to ensure that the viral/bacterial load of the room becomes as close to zero. Since, zero was the baseline of each room.

Step 3: Conduction of various aerosol and non-aerosol generating procedures in the sanitized operatory.

Step 4: Collection of the sample from various sites at varying time intervals within the operatory room.

Step 5: Culturing the sample with qualitative and quantitative analysis.

The Process Of Group Allocation

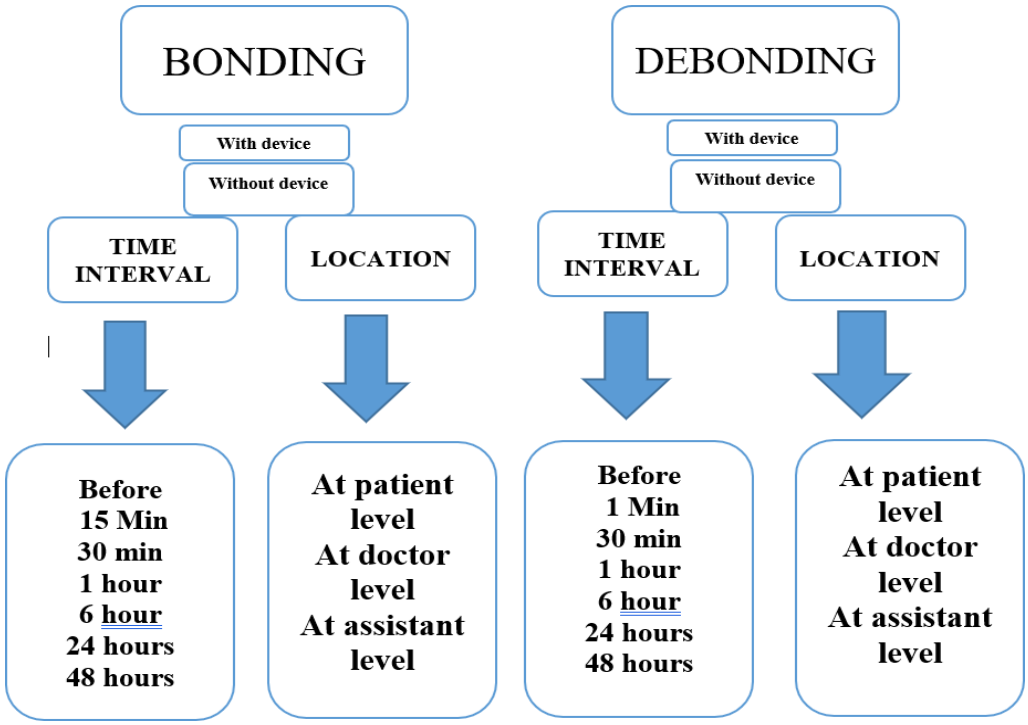

Figure 1. Pain intensity in Group NSAIDs and Group TCA in follow up

The collected samples were sent for culturing and the culture growth was examined at the above-mentioned intervals to assess the change in the quality and quantity of microflora at various time intervals. The cultures were assessed until the bacterial/viral load of the petri-dishes reaches to baseline zero again. When the cultures consistently arrive at zero baseline for 2 or 3 consecutive days, then it would be assumed that the viral/bacterial load are no longer multiplying, i.e, they have reached their stable position and this was end the 1st phase of the experiment. The procedure was repeated before and after usage of UV tunnel for determining its efficacy in both bonding as well as debonding and the results were analyzed both qualitatively as well as quantitatively.

STATISTICAL ANALYSIS

Data were analysed using descriptive statistics. The acquired data was analyzed using SPSS version 21 software. The current study included both descriptive and inferential statistical analysis. Continuous measurement findings were provided as Mean ± SD, whereas categorical measurements were presented as a percentage. The level of significance was set at p = 0.05, and any value less than or equal to 0.05 was considered statistically significant. Chi square analysis was performed to determine the relevance of study parameters on a categorical scale.

TABLE 1. Mean Scores for TVC & TMC at different time intervals

	Group	N	Mean	Std. Deviation
Efficacy 15 min	TVC	8	12.2375	10.42012
	TMC	8	34.0650	22.23930
Efficacy 30 min	TVC	8	27.6413	13.37588
	TMC	8	53.4988	17.14093
Efficacy 1 hours	TVC	8	48.5688	8.32253
	TMC	8	63.1663	16.53527
Efficacy 6 hours	TVC	8	67.1050	1.36582
	TMC	8	70.6075	13.10542
Efficacy 24 hours	TVC	8	81.2988	3.10276
	TMC	8	76.9263	12.09200
Efficacy 48 hours	TVC	8	86.8188	4.31143
	TMC	8	90.9513	8.30007

The data was collected at different time intervals, from 15 minutes to 48 hours. **Table 1** shows the mean scores for both groups at these different time intervals. At every interval, TVC showed lower values than TMC except at 24 hours, 81.29 ± 3.1 & 76.92 ± 12.09, respectively.

TABLE 2. Comparative Evaluation Of TVC And TMC At Different Time Intervals

Dependent Variable	Group	Group	Mean Difference	Sig.
TVC efficacy	15 min	30 min	-15.40375*	.005
		1 hour	-36.33125*	.000
		6 hours	-54.86750*	.000
		24 hours	-69.06125*	.000
		48 hours	-74.58125*	.000
	30 min	15 min	15.40375*	.005
		1 hour	-20.92750*	.000
		6 hours	-39.46375*	.000
		24 hours	-53.65750*	.000
		48 hours	-59.17750*	.000
	1 hour	15 min	36.33125*	.000
		30 min	20.92750*	.000
		6 hours	-18.53625*	.000
		24 hours	-32.73000*	.000
		48 hours	-38.25000*	.000
	6 hours	15 min	54.86750*	.000
		30 min	39.46375*	.000
		1 hour	18.53625*	.000
		24 hours	-14.19375*	.012
		48 hours	-19.71375*	.000
	24 hours	15 min	69.06125*	.000
		30 min	53.65750*	.000
		1 hour	32.73000*	.000
		6 hours	14.19375*	.012
		48 hours	-5.52000	.741
	48 hours	15 min	74.58125*	.000
		30 min	59.17750*	.000
		1 hour	38.25000*	.000
		24 hours	19.71375*	.000
		48 hours	5.52000	.741

TMC efficacy	15 min	30 min	-19.43375	.147
		1 hour	-29.10125*	.007
		6 hours	-36.54250*	.000
		24 hours	-42.86125*	.000
		48 hours	-56.88625*	.000
	30 min	15 min	19.43375	.147
		1 hour	-9.66750	.813
		6 hours	-17.10875	.258
		24 hours	-23.42750*	.046
		48 hours	-37.45250*	.000
	1 hour	15 min	29.10125*	.007
		30 min	9.66750	.813
		6 hours	-7.44125	.929
		24 hours	-13.76000	.495
		48 hours	-27.78500*	.011
	6 hours	15 min	36.54250*	.000
		30 min	17.10875	.258
		1 hour	7.44125	.929
		24 hours	-6.31875	.963
		48 hours	-20.34375	.115
	24 hours	15 min	42.86125*	.000
		30 min	23.42750*	.046
		1 hour	13.76000	.495
		6 hours	6.31875	.963
		48 hours	-14.02500	.474
	48 hours	15 min	56.88625*	.000
		30 min	37.45250*	.000
		1 hour	27.78500*	.011
		24 hours	20.34375	.115
		48 hours	14.02500	.474

Table 2 shows the comparative evaluation of the two groups at different time intervals.

TABLE 3. Descriptive statistics for the TVC group at different time intervals with and without UV device

Time intervals	Group	N	With UV Device		Without UV Device	
			Mean	Std. Deviation	Mean	Std. Deviation
TVC Before	Bonding	4	175.7500	12.01041	173.7500	1.01841
	Debonding	4	204.7500	8.13941	207.7500	9.13041
TVC 15 min	Bonding	4	143.2500	23.47161	140.1500	11.47161
	Debonding	4	192.5000	5.56776	187.2000	5.59076
TVC 30 min	Bonding	4	106.2500	10.01249	116.2500	9.01249
	Debonding	4	172.2500	5.90903	198.2500	5.87003
TVC 1 hour	Bonding	4	80.5000	11.67619	81.5000	10.67619
	Debonding	4	116.0000	5.35413	126.0000	5.35413
TVC 6 hours	Bonding	4	57.7500	2.62996	87.7600	2.72996
	Debonding	4	67.2500	2.21736	77.4500	3.21736
TVC 24 hours	Bonding	4	28.2500	2.50000	35.2500	9.50000
	Debonding	4	43.5000	3.00000	78.5000	3.56000
TVC 48 hours	Bonding	4	17.7500	5.85235	65.7500	9.89235
	Debonding	4	33.0000	4.54606	90.0000	8.49606

Table 3 shows the mean scores of the TVC group in Bonding and Debonding before the intervention and at all the time intervals. The values for debonding are higher than the bonding values, and all with UV device values progressively decrease from before intervention 175.75 ± 12 bonding, 204.75 ± 8.1 debonding to 48 hours 17.75 ± 5.8 & 33 ± 4.5, respectively. Such a trend was not observed without the UV device values. However, higher values were observed in debonding than in bonding.

TABLE 4. Comparative evaluation of TVC at different distances with & without UV device

Parameter	Group	With UV device			Without UV device		
		T	MD	P value	T	MD	P value
TVC Before	Bonding	.812	-29.00000	.007*	-.078	-32.00000	.007*
	Debonding						
TVC 15 min	Bonding	4.286	-49.25000	.006*	-.126	-37.25000	.006*
	Debonding						
TVC 30 min	Bonding	.536	-66.00000	.000*	-.196	-58.00000	.000*
	Debonding						
TVC 1 hour	Bonding	11.022	-35.50000	.001*	-.063	-43.50000	.001*
	Debonding						
TVC 6 hours	Bonding	.020	-9.50000	.001*	-.078	-43.50000	.001*
	Debonding						
TVC 24 hours	Bonding	.794	-15.25000	.000*	-.126	-35.25000	.000*
	Debonding						
TVC 48 hours	Bonding	.332	-15.25000	.006*	-.196	-15.25000	.006*
	Debonding						

*Statistically significant ($p < 0.05$)

Table 4 shows the mean difference between bonding and debonding scores at different time intervals. The difference found was significant statistically in both the with & without UV groups at every time interval.

TABLE 5. Descriptive statistics for the TVC group at different time intervals with debonding & bonding procedure

Time interval	Group	N	Debonding		Bonding	
			Mean	Std. Deviation	Mean	Std. Deviation
TVC Before	With device	4	171.2500	12.01041	165.7500	1.01841
	Without device	4	206.2500	8.13961	201.7500	9.13041
TVC 15 min	With device	4	146.1500	13.47161	130.1500	31.47161
	Without device	4	196.5000	9.56776	197.2000	5.59076
TVC 30 min	With device	4	111.2500	60.01249	166.2500	6.01249
	Without device	4	162.2500	05.90903	178.2500	9.87003
TVC 1 hour	With device	4	78.5000	12.67619	80.5000	11.67619
	Without device	4	106.0000	5.95413	136.0000	7.35413
TVC 6 hours	With device	4	77.7500	12.62996	87.9600	9.72996
	Without device	4	65.2500	21.21736	77.8500	6.21736
TVC 24 hours	With device	4	45.2500	12.50000	35.2500	5.50000
	Without device	4	43.5000	3.00000	98.5000	6.56000
TVC 48 hours	With device	4	27.7500	5.85235	65.7500	4.89235
	Without device	4	36.0000	1.54606	80.0000	9.49606

Table 5 depicts the Mean & SD for debonding and bonding devices at different time intervals. For the debonding device gradual decrease was seen in the scores as the time increased, whereas no such observation was made in the bonding group. However, in both groups scores for without the UV device were higher than in with device.

Table 6. Comparative evaluation of TVC at different distances with debonding & bonding procedures.

Parameter	Group	Debonding			Bonding		
		T	MD	P value	T	MD	P value
TVC Before	With device	.812	-9.00000	.000*	-.078	-22.00000	.009*
	Without device						
TVC 15 min	With device	4.286	-37.25000	.006*	-.126	-47.25000	.008*
	Without device						
TVC 30 min	With device	.536	-45.00000	.010*	-.196	-98.00000	.000*
	Without device						
TVC 1 hour	With device	11.022	-65.50000	.001*	-.063	-33.50000	.001*
	Without device						
TVC 6 hours	With device	.020	-19.50000	.001*	-.078	-63.50000	.001*
	Without device						
TVC 24 hours	With device	.794	-25.25000	.010*	-.126	-75.25000	.000*
	Without device						
TVC 48 hours	With device	.332	-15.25000	.006*	-.196	-25.25000	.007*
	Without device						

Table 6 gives the mean difference in the scores for with and without UV devices at different distances with debonding & bonding procedures. The difference was statistically significant for all time intervals,

Table 7. Descriptive statistics for the TMC group at different time intervals with & without device

Parameter	Group	N	With device		Without device	
			Mean	Std. Deviation	Mean	Std. Deviation
TMC Before	**Bonding**	4	7.0000	.81650	8.0000	.81050
	Debonding	4	11.5000	4.35890	10.5000	7.35890
TMC 15 min	**Bonding**	4	5.2500	.50000	6.2500	1.50000
	Debonding	4	6.0000	3.55903	7.0000	5.55903
TMC 30 min	**Bonding**	4	3.7500	.95743	5.7500	2.95743
	Debonding	4	4.5000	3.10913	7.5000	1.10913
TMC 1 hour	**Bonding**	4	3.0000	.81650	3.0000	0.81650
	Debonding	4	3.2500	2.50000	3.2500	6.50000
TMC 6 hours	**Bonding**	4	2.2500	.50000	3.2500	.50000
	Debonding	4	2.7500	2.21736	3.7500	.21736
TMC 24 hours	**Bonding**	4	1.7500	.50000	2.7500	7.50000
	Debonding	4	2.0000	1.41421	2.0000	2.41421
TMC 48 hours	**Bonding**	4	.5000	.57735	.5000	3.57735
	Debonding	4	1.0000	.81650		

A similar analysis was done for the TMC group. The following tables show the results obtained.
For the TMC group, mean values at different time intervals in with UV device and without UV device group are given in **Table 7.**

Table 8. Comparative evaluation of TMC at different distances with & without device

Parameter	Group	With device			Without device		
		t value	MD	P value	t value	MD	P value
TMC Before	**Bonding**	-2.029	-4.50000	.089	-6.029	-4.50000	.081
	Debonding						
TMC 15 min	**Bonding**	-.417	-.75000	.691	-.717	-.75000	.871
	Debonding						
TMC 30 min	**Bonding**	-.461	-.75000	.661	-.962	-.75000	.461
	Debonding						
TMC 1 hour	**Bonding**	-.190	-.25000	.855	-.990	-.25000	.805
	Debonding						
TMC 6 hours	**Bonding**	-.440	-.50000	.675	-.840	-.50000	.615
	Debonding						
TMC 24 hours	**Bonding**	-.333	-.25000	.750	-.343	-.25000	.150
	Debonding						
TMC 48 hours	**Bonding**	-1.000	-.50000	.356	-1.000	-.50000	.206
	Debonding						

The mean difference at each time interval in TMC group for with UV device and without UV device groups are given in **Table 8.**

Table 9. Descriptive statistics for the TMC group at different time intervals with debonding & bonding procedures.

Parameter	Group	N	Debonding		Bonding	
			Mean	Std. Deviation	Mean	Std. Deviation
TMC Before	With device	4	6.0000	1.00650	9.0000	.78050
	Without device	4	10.5000	2.35890	9.5000	4.35890
TMC 15 min	With device	4	6.2500	.57000	6.2500	1.50000
	Without device	4	6.0000	3.55903	6.0000	3.55903
TMC 30 min	With device	4	4.7500	.85743	5.7500	2.95743
	Without device	4	4.5000	2.10913	6.5000	0.10913
TMC 1 hour	With device	4	3.0000	.71650	4.0000	0.81650
	Without device	4	2.2500	2.70000	3.2500	1.50000
TMC 6 hours	With device	4	3.2500	.50800	4.2500	.57000
	Without device	4	3.7500	2.71736	3.7500	.21736
TMC 24 hours	With device	4	2.7500	.50000	1.7500	7.57000
	Without device	4	3.0000	1.41021	2.0000	1.41021
TMC 48 hours	With device	4	1.5000	.67735	.5000	3.57135
	Without device	4	1.5000	.87650	1.0000	2.81650

Table 9 shows the mean and SD values at different time intervals with debonding and bonding procedures. The values decrease progressively as the time interval increases.

4.DISCUSSION

Aerosols are likely to be produced during proximal stripping, banding, debonding, and other procedures in the active phase of orthodontic therapy. Upon completion of the active orthodontic treatment period, the bands and bonded attachments are extracted. The excess adhesive on the teeth can be eliminated using specialized pliers. Utilize a dome-tapered tungsten carbide bur in a high-speed dental handpiece, operating at about 30,000 rpm, to eliminate any residual adhesive from the tooth surface. To avert damage or necrosis of the dental pulp, a water spray is affixed to cool the handpiece tip with water. This subsequently results in the development of aerosols around the operatory, raising infection concerns for the orthodontist, dental assistants, and the patient[8–10]. Mitigating airborne infections is essential in dental environments since they can disseminate bacteria and viruses, presenting a health hazard to orthodontists, patients, and staff. HEPA air filters are exceptionally efficient at diminishing bioaerosols, hence mitigating airborne illnesses. Recent advancements, such as UV air sanitizers devoid of a HEPA filter (UV Tunnel device), assert that the likelihood of re-contamination is diminished as they emit inactive or killed microorganisms alongside purified air, thereby serving as a catalyst for immune response among healthcare professionals, without the risk of disease causation or progression. Ten The efficacy was evaluated as one of the parameters at various time intervals for both TVC and TMC. The estimated mean ratings revealed that efficacy improved with the passage of time.

According to Day CJ (2008), the aerosols generated during orthodontic bonding and debonding are often inhaled irrespective of handpiece speed in the presence or absence of water coolant, and as a result, aerosol-generating orthodontic procedures should be briskly assessed for timely prevention of respiratory diseases and maintenance of systemic health of the orthodontists[13–15]. Efficacy was one of the factors measured at various time intervals for both TVC and TMC. According to the estimated mean scores, efficacy increased with time. Similarly, TVC and TMC were examined at various time intervals, with the exception of 24 and 48 hours, showing a significant difference in both groups. The mean TVC count decreased as time passed. The bonding group showed the greatest reduction when compared to the non-bonding group with devices. The TMC was assessed at different levels from the patient's oral cavity. There was a significant difference seen between patient level and doctor as well as assistant level even after 48 hours. However, there was no statistical difference at the doctor and patient level in both debonding and bonding generating groups.

Bonding and debonding techniques should be the main emphasis of realistic management in practice, and it is essential to carefully choose procedures and apply

safety measures based on each patient's unique demands[16]. Taken together, particulate matter production, toxicity, and microbiologic issues should all be taken into account when implementing widespread and uniform occupational controls to limit aerosol creation in orthodontic practices[17,18].

5. CONCLUSION

An array of aerosols continues to circulate in moderately turbulent air within the dental setup; therefore, it is largely required to reduce bio-burden during orthodontic treatments in order to protect orthodontists from hazardous aerosol exposure. Furthermore, UV radiation, due to its natural ability to damage DNA by producing dimerization of pyrimidines, is extremely effective in lowering the bio-burden of contaminated aerosol. As a result of this evidence, it is very obvious that UV tunnel devices not only demonstrate a statistically significant drop among viable mould, but also reduce the likelihood of re-contamination.

DECLARATIONS

Ethical approval and consent to participate

Not Applicable

Availability of data and material

All data generated or analyzed during this study are included in the published article.

Competing interest

The authors declare that there are no competing interests.

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