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Comparative Analysis of Two Fumigating Agents in Reducing Aerosol Microbial Load After Ultrasonic Scaling

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Abstract:

- ***Aim-***

Aerosols that are generated in dental environment during ultrasonic scaling may cause problems for health of dentists and patients. It is therefore important for dentists to adopt best practices in reducing the risk of infectious disease through aerosols by evaluating the aerosol mitigation interventions. Therefore, the aim of the study was to compare the efficacy of two fumigating agents in reducing aerosol microbial count (CFU) before and after ultrasonic scaling at different time intervals.

- ***Methods-***

Ultrasonic scaling was performed on 30 systemically and periodontally healthy subjects. 10 patients each were divided into 3 groups- Group 1- (control) No fumigation, Group 2- fumigation using agent 1 (ammonium compound +silver nitrate), Group 3- fumigation using agent 2(hydrogen peroxide +silver nitrate). The active air sampling method was used to collect aerosols using MAS100 sampler at time intervals- before, immediately after, one hour and two hours later ultrasonic scaling (T0, T1, T2, T3).

- ***Results-***

Fumigating agent 2 demonstrated superior performance in maintaining lower CFU compared to other groups suggesting it to be a more effective agent for reducing microbial contamination in dental cabin.

- ***Conclusion-***

The study highlights the importance of using fumigating agents in dental cabins to control colony factor units (CFU) levels before and after ultrasonic scaling.

Keywords: *Aerosols, Microorganisms, Fumigation, Ultrasonic Scaling.*

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I. INTRODUCTION

An aerosol is defined as a suspension of fine solid particles or liquid droplets dispersed in air or another gaseous medium. [1,2]The term generally refers to a mixture of particulate matter suspended in the air. In dentistry, the concepts of “aerosol” and “splatter” were first introduced by Micik and co-workers in their foundational aerobiology studies. [3-6]Aerosol particles that measure between 0.5 and 10 µm are of particular concern, as they can penetrate deep into the lower respiratory tract and are believed to pose the highest risk for disease transmission. It is widely accepted that particles less than 50 µm in diameter represent the greatest airborne infection risk in dental settings because of their ability to remain suspended in the air and enter the respiratory system.[7-12]

Several dental procedures, including scaling with sonic and ultrasonic scalers, air polishing, and tooth preparation using air turbine handpieces or air abrasion, are known to generate significantly higher quantities of aerosols compared to other treatments. [13,14,15]Numerous investigations have

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attempted to identify which procedures produce the highest levels of airborne microbial contamination.[16-20]

Controlling the dispersion of aerosol clouds is essential to ensure the safety of both patients and dental professionals. During routine dental procedures, aerosols may contain microorganisms from saliva, blood, and supra- and subgingival plaque, including viruses and bacteria. The use of antimicrobial agents such as chlorhexidine and povidone iodine as irrigants or coolants during ultrasonic scaling has been shown to reduce microbial contamination. In addition, the application of rubber dams along with saliva ejectors or low-volume evacuators helps in limiting the escape of aerosols from the oral cavity.[21]

Once aerosols disperse into the clinical environment, air purification strategies can be employed to reduce contamination levels. These include the use of high-efficiency particulate air (HEPA) filters, discouraging the use of fans that may recirculate contaminated air, improving ventilation by keeping windows open, and installing exhaust systems in the operatory.

Certain methods are capable of directly decontaminating airborne particles, such as ultraviolet irradiation, ozonization, and fumigation. Fumigation is a chemical process in which substances like formaldehyde and potassium permanganate are used to disinfect the air in clinical or operating room environments.[22-32]

Maintaining a contamination-free dental environment is essential to provide a hygienic and safe workspace. Formaldehyde fumigation has been proven effective in reducing microorganisms such as *Staphylococcus aureus*, *Streptococcus* species, *Escherichia coli*, and *Aspergillus* species due to its strong antimicrobial properties. However, because of its carcinogenic potential, formaldehyde is now rarely used, and fogging techniques are preferred. Fogging typically involves a solution of hydrogen peroxide combined with silver ions, which exerts a bactericidal effect on suspended microorganisms. Other alternatives that have been explored include silver nitrate and quaternary ammonium compounds. Therefore, before selecting a fumigating agent for use in a dental setting, it is important to accurately measure the concentration of aerosols present in the environment.[33,34]

Aerosol levels can be determined using physical sampling techniques involving the aspiration, transportation, and deposition of particles onto a collection medium. [35-37]These sampling methods may be either passive or active in nature. Active sampling involves the use of microbiological air samplers such as the BIAFTS system, which draws in a specific volume of air and collects microorganisms onto solid or liquid culture media. The microbial load obtained is then expressed as colony-forming units per cubic meter (CFU/m³) of air.[38-45]

While many studies have focused on the distance and spatial distribution of aerosol and splatter contamination in dental clinics, the actual microbial load within these aerosols has not been extensively or adequately investigated. Therefore, it is essential for dental professionals to follow evidence-based infection control practices and to assess the effectiveness of various aerosol mitigation strategies in order to minimize the risk of airborne disease transmission in dental environments.

Therefore, the aim of the present study was to assess microbial air count in the dental environment with active air sampling at the beginning, during, and after two hours of ultrasonic scaling in periodontally healthy subjects. Since there are few studies on fumigating agents apart from hydrogen peroxide and formaldehyde, therefore this study is to compare the efficacy of two disinfecting agents in reducing the aerosols after ultrasonic scaling.

➢ *Aim-*

To evaluate and compare the efficacy of two fumigating agents – ammonium chloride + silver nitrate with hydrogen peroxide + silver nitrate in reducing the microorganisms contained in aerosols post the aerosol generating procedures (AGP) at different time intervals.

➢ *Objectives-*

- To assess the microbial load contained in aerosols at time interval T0 -before ultrasonic scaling
- To assess the microbial load contained in aerosols at time interval T1 –immediately after ultrasonic scaling
- To assess the microbial load contained in aerosols at time interval T2 –one hour after ultrasonic scaling
- To assess the microbial load contained in aerosols at time interval T3- three hours after ultrasonic scaling
- To evaluate the effectiveness of fumigating agent-FUMISAN in reducing the microorganisms contained in aerosols at time interval T0 -before ultrasonic scaling
- To evaluate the effectiveness of fumigating agent-FUMISAN in reducing the microorganisms contained in aerosols at time interval T1 -immediately after ultrasonic scaling
- To evaluate the effectiveness of fumigating agent-FUMISAN in reducing the microorganisms contained in aerosols at time interval T2 -one hour after ultrasonic scaling
- To evaluate the effectiveness of fumigating agent-FUMISAN in reducing the microorganisms contained in aerosols at time interval T3 -two hours after ultrasonic scaling
- To evaluate the effectiveness of fumigating agent-SILVICIDE in reducing the microorganisms contained in aerosols at time interval T0 -before ultrasonic scaling
- To evaluate the effectiveness of fumigating agent-SILVICIDE in reducing the microorganisms contained in aerosols at time interval T1 -immediately after ultrasonic scaling
- To evaluate the effectiveness of fumigating agent-SILVICIDE in reducing the microorganisms contained in aerosols at time interval T2 -one hour after ultrasonic scaling

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- To evaluate the effectiveness of fumigating agent- SILVICIDE in reducing the microorganisms contained in aerosols at time interval T3 -two hours after ultrasonic scaling
- To compare the effectiveness of both the fumigating agents- FUMISAN and SILVICIDE in reducing the microorganisms contained in aerosols

II. STUDY DESIGN- EXPERIMENTAL STUDY

➢ *Period of Study- 3 Months*

- *Source of Data:*

Outpatients visiting the Department of Periodontics, D.A.P.M.R.V Dental College, Bangalore

- Sample Size- 30

➢ *Sample Size Estimation*

- Analysis: A priori: Compute required sample size
- Input: Effect size f = 0.60, α err prob = 0.05, Power (1-β err prob) = 0.80
- Number of groups = 3
- Output: Non centrality parameter λ = 10.8000000
- Critical F = 3.3541308
- Numerator df = 2, Denominator df = 27
- Total sample size = 30
- Actual power = 0.8004441

The sample size for the present study was estimated using GPower software (latest ver. 3.1.9.7; Heinrich-Heine-Universi-ta¨t Du¨sseldorf, Du¨sseldorf, Germany).

The sample size estimation was performed at 5% alpha error (α = 0.05), with an effect size of 0.60 [Based on the findings from the previous literature by Malkit Singh et al, 2012 for the mean difference in the log reduction in the bacterial load b/w groups] & the power of the study at 80%, demonstrated that a minimum of 30 samples will be needed for the present study. So, each study group will consist of 10 samples [10 samples x 3 groups = 30 samples].

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., will be used to perform statistical analyses.

- Descriptive Statistics: - will be done using frequency and proportions for categorical variables, whereas in Mean & SD for continuous variables.
- Inferential Statistics: One-way ANOVA Test followed by Tukey's post hoc test was used to compare the mean CFUs between 3 groups at different time intervals.

Independent Student t Test was used to compare the mean CFUs immediately after fumigation 6 feet away from chair between Group II & Group III.

Repeated Measures of ANOVA Test followed by Bonferroni's post hoc test was used to compare the mean CFUs between different time intervals in each group.

The level of significance was set at $p<0.05$.

III. METHODOLOGY

➢ *Inclusion Criteria:*

- Patients having plaque and calculus and are indicative for ultrasonic scaling
- Patients who are systemically healthy
- Age between 25 and 45 years.

➢ *Exclusion Criteria:*

- Pregnant and lactating patients
- Chronic smokers
- Patients with uncontrolled diabetes and immuno-compromised patients
- Patient with a history of chronic obstructive pulmonary disease and bronchial asthma

➢ *Materials*

- Mouth mirror and explorers
- Kidney tray
- Suction tip
- Ultrasonic scaler tip
- Disposable gloves, head caps, mouth masks
- Air sampler
- Fumigator device
- Fumigating agents – FUMISAN and SILVICIDE

- Composition of FUMISAN- Octyl Decyl Dimethyl Ammonium Chloride: 0.1% w/v and Silver Nitrate: 0.01% w/v with Neem extracts
- Composition of SILVICIDE- 0.01% w/v Silver nitrate IP, 10% w/v Hydrogen Peroxide IP.

➢ *Methods*

Subjects were selected from those having plaque and calculus and are indicative for scaling 30 patients were selected and divided into 3 groups- each study group consisted of 10 samples [10 samples x 3 groups = 30 samples].

➢ *Clinical-*

- *Group I (10 Patients)-*

Ultrasonic scaling was performed in dental cabin

- *Group II (10 Patients)-*

Ultrasonic scaling was performed in dental cabin that was disinfected with agent 1- FUMISAN

- *Group III (10 Patients)-*

Ultrasonic scaling was performed in dental cabin that was disinfected with agent 2- SILVICIDE

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➢ *In Each Group,*

- *T0- Before Start of Ultrasonic Scaling*

After isolating the dental setup for 24 hours, aerosol samples were collected using air sampler to determine the presence of microorganism in the operating setup before the ultrasonic scaling procedure.

- *T1- Immediately After Ultrasonic Scaling is Done*

Aerosol Samples were collected immediately after ultrasonic scaling was performed on patient.

Fumigation with the respective agents was done using a fumigator once at T0 and at T1 time intervals in respective groups.

- *T2- One Hour After Ultrasonic Scaling is Done*

Aerosol Samples were collected from operating setup an hour after ultrasonic scaling was done

- *T3- Three Hours After Ultrasonic Scaling is Done*

For Groups II and III- Fumigation with disinfectants- FUMISAN and SILVICIDE respectively.

All the procedures and sample collection were performed in isolated dental cabin.

➢ *For Fumigation of the Dental Cabin*

Usage directions for aerial fumigation-

- Use 1:5 silvicide i.e., 200 ml silvicide + 800 ml water
- Similar directions were followed for FUMISAN agent.
- The fumigants were diluted to the working concentration and loaded in the fumigator to be used.
- Aerosol samples were collected using air sampler after fumigation was done using respective disinfectants.
- The air sampler which was used in the study is MAS100 sampler.

The MAS-100 VF® microbial air monitoring system is a high-performance, portable, battery-operated device that functions based on the Andersen air sampling principle. These compact yet advanced instruments are widely preferred for high-quality microbial air analysis. A measured volume of ambient air is drawn through a perforated lid containing 300 holes, passing through an aluminium sampling head and adapter onto a Petri dish containing nutrient agar, a general-purpose medium suitable for the collection of a broad range of bacterial species.

Air sampling was carried out for a duration of five minutes at a flow rate of 180 L/min. During each procedure, the air sampler was positioned 30 cm from the dental chair and 1.5 m above the floor, corresponding to the approximate breathing zone of the patient. Airborne microorganisms impacted onto the agar surface, and following an appropriate incubation period, the resulting colonies were counted.

The agar plates were incubated at 36 ± 2°C for 24 to 72 hours, after which the microbial colonies were enumerated. These colony counts were subsequently converted into airborne microbial concentrations and expressed as colony-forming units per cubic meter of air (CFU/m³).[40-47]

➢ *For all the Three Groups -Ultrasonic Scaling Procedure is Performed-*

Mouth rinsing with chlorhexidine 0.20% was performed in all patients immediately before the procedure. Supragingival scaling was performed by a single operator, equipped with a disposable gown and cap, face mask, and face shield, using the ultrasonic dental scaler with an independent source of distilled water and a sterile standard tip under a 150 L/min flow rate suction with a disposable saliva ejector placed in the corner of the mouth opposite of the quadrant to be treated.

The tip was kept in contact with the teeth as much as possible during the procedure and is cooled with a fine water spray. The duration of each treatment is approximately 20-30 mins.

IV. RESULTS

In this study, colony counting on settle plate method has been used where each colony dot has been counted once, ideally on a grid of cells.

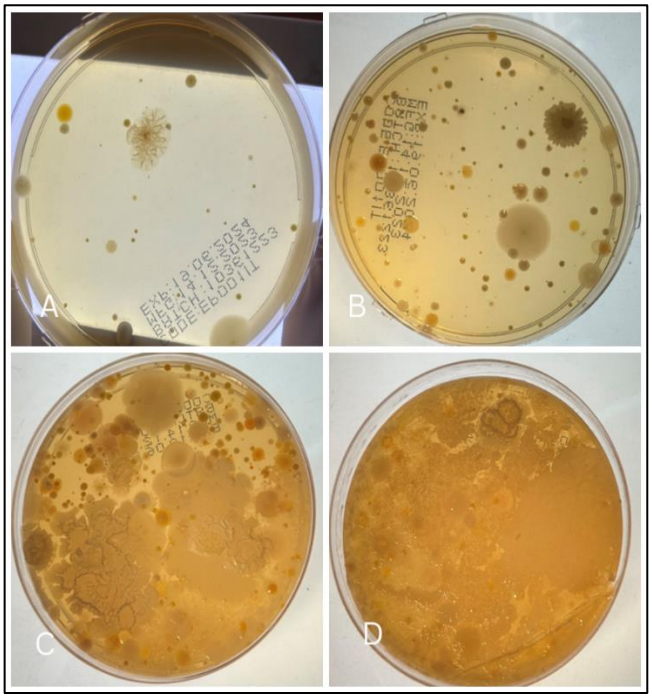

Fig 1 Group I No Fumigation – Only One Culture Plate

A- Before Treatment
B- After Ultrasonic Scaling
C- One Hour After Scaling
D- Two Hours After Scaling

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Sl No. of Patients	A-Before Treatment	B-Immediately After Treatment	C-One Hour After the Treatment	D- Two Hours After the Treatment
1	25	75	300	650
2	27	66	343	644
3	23	69	350	666
4	30	79	347	649
5	39	77	329	700
6	29	72	289	630
7	33	70	370	649
8	27	80	331	634
9	31	75	323	598
10	35	77	329	632

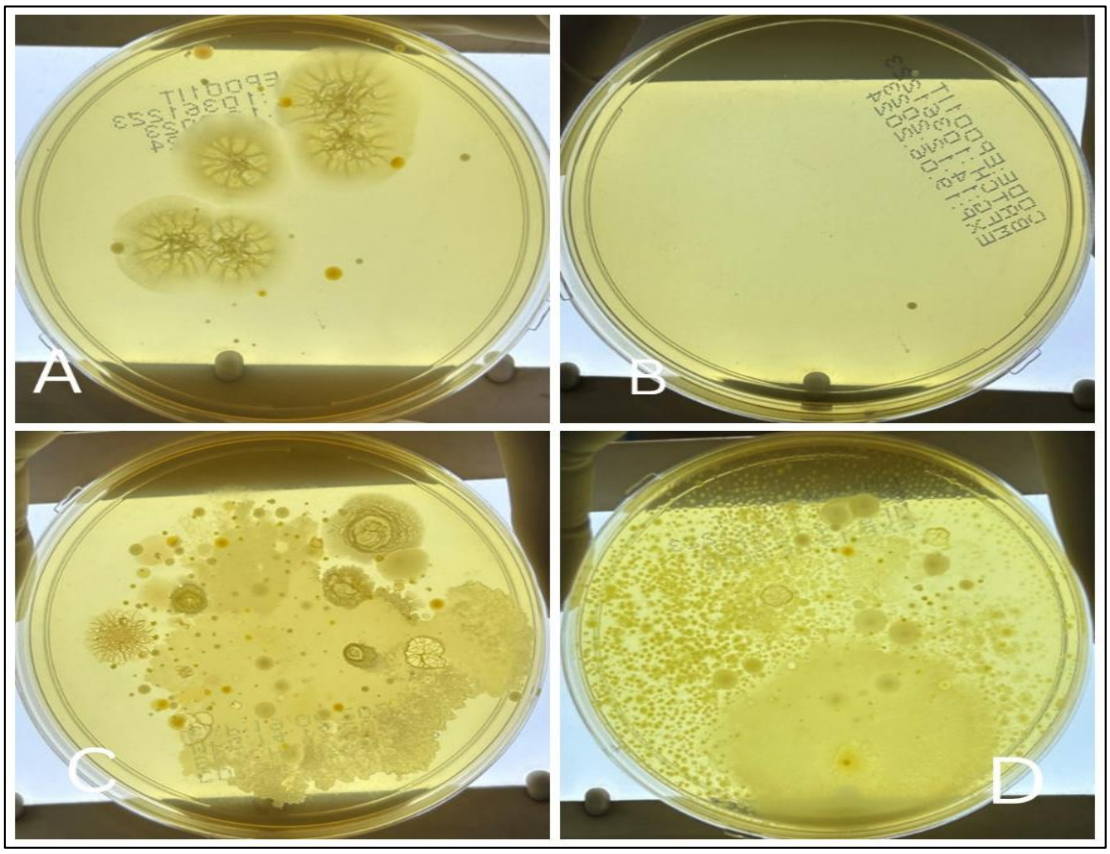

Fig 2 Group II- Fumigating with Agent 1- Fumisan

A- Before Treatment
B- After Ultrasonic Scaling
C- One Hour After Scaling
D- Two Hours After Scaling

Sl. No of Patients	A-Immediately After Fumigation Before Treatment	B-Immediately After Treatment	C-One Hour After Treatment	D-Two Hours After Treatment
1	17	2	200	500
2	20	4	265	489
3	15	1	221	576
4	14	3	230	514
5	17	2	240	510
6	15	1	189	490
7	12	2	202	510
8	15	2	220	500
9	14	4	230	555
10	19	5	223	540

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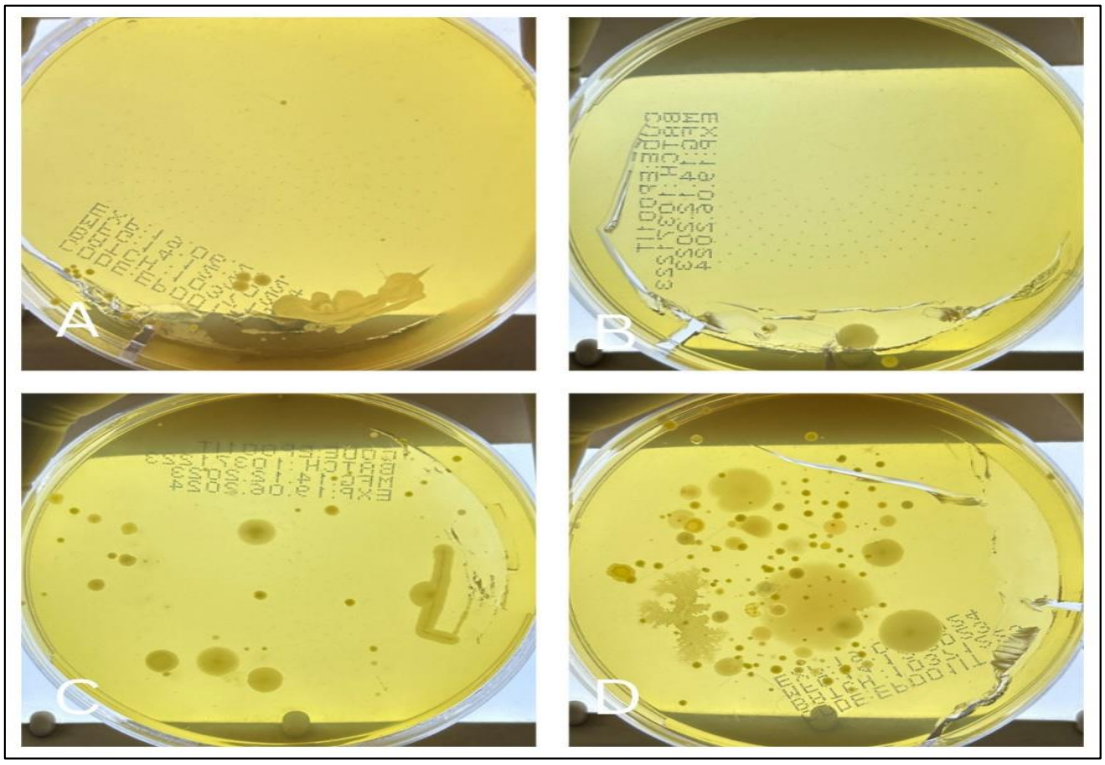

Fig 3 Group III – Fumigation with Agent 2-Silvicide

Sl. No of Patients	A-Immediately After Fumigation Before Treatment	B- Immediately After Treatment	C-One Hour After Treatment	D-Two Hours After Treatment
1	15	4	40	140
2	13	5	45	120
3	14	6	50	144
4	15	3	31	152
5	18	4	34	136
6	14	7	39	135
7	12	2	30	129
8	14	4	33	130
9	10	6	40	140
10	12	5	39	149

- *MAS 100 SAMPLER which was Used for Active Air Sampling*

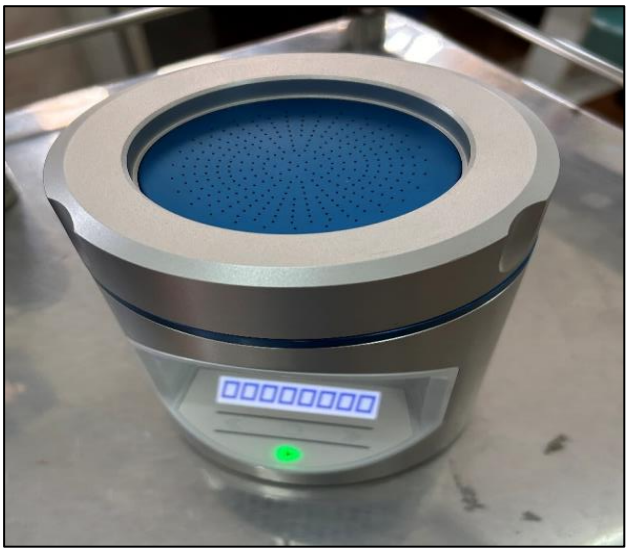

Fig 4 MAS 100 SAMPLER which was Used for Active Air Sampling

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Table 1 Comparison of Mean CFUs Between 3 Groups at Different Time Intervals Using One-Way ANOVA Test Followed by Tukey's Post Hoc Test

Time	Groups	N	Mean	SD	p-value [a]	Sig. Diff	p-value [b]
T0	Group I	10	29.90	4.82	<0.001*	I vs II	<0.001*
	Group II	10	15.80	2.44		I vs III	<0.001*
	Group III	10	13.70	2.16		II vs III	0.36
T1	Group I	10	74.00	4.60	<0.001*	I vs II	<0.001*
	Group II	10	2.60	1.35		I vs III	<0.001*
	Group III	10	4.60	1.51		II vs III	0.29
T2	Group I	10	331.10	23.76	<0.001*	I vs II	<0.001*
	Group II	10	222.00	21.81		I vs III	<0.001*
	Group III	10	38.10	6.30		II vs III	<0.001*
T3	Group I	10	645.20	26.35	<0.001*	I vs II	<0.001*
	Group II	10	518.40	29.12		I vs III	<0.001*
	Group III	10	137.50	9.66		II vs III	<0.001*

*Statistically Significant

- Note: T0 – Before start of ultrasonic scaling; T1 - Immediately after ultrasonic scaling is done; T2 - One hour after ultrasonic scaling was done & T3 – Two hours after ultrasonic scaling was done

At time T0, Group I had a mean CFU of 29.90 ± 4.82. Group II had a mean of 15.80 ± 2.44, while Group III had a mean of 13.70 ± 2.16. The test results indicated significant differences between the groups at $p < 0.001$. Multiple comparison tests showed significantly higher CFUs in Group I as compared to Group II and Group III, with the mean differences being statistically significant at $p < 0.001$, respectively. However, there was no statistically significant difference in the mean CFUs between Group II and Group III ($p = 0.36$). At time T1, Group I had a mean CFU of 74.00 ± 4.60. Group II had a mean of 2.60 ± 1.35, while Group III had a mean of 4.60 ± 1.51. The test results indicated significant differences between the groups at $p < 0.001$. Multiple comparison tests showed significantly higher CFUs in Group I as compared to Group II and Group III, with the mean differences being statistically significant at $p < 0.001$, respectively. However, there was no statistically significant difference in the mean CFUs between Group II and Group III ($p = 0.29$). At time T2, Group I had a mean CFU of 331.10 ± 23.76. Group II had a mean of 222.00 ±21.81, while Group III had a mean of 38.10 ± 6.30. The test results indicated significant differences between the groups at $p < 0.001$. Multiple comparison tests showed significantly higher CFUs in Group I as compared to Group II and Group III, with the mean differences being statistically significant at $p < 0.001$, respectively. Additionally, there was a statistically significant difference in the mean CFUs between Group II and Group III ($p < 0.001$). At time T3, Group I had a mean CFU of 645.20 ± 26.35. Group II had a mean of 518.40 ±29.12, while Group III had a mean of 137.50 ± 9.66. The test results indicated significant differences between the groups at $p < 0.001$. Multiple comparison tests showed significantly higher CFUs in Group I as compared to Group II and Group III, with the mean differences being statistically significant at $p < 0.001$, respectively. Additionally, there was a statistically significant difference in the mean CFUs between Group II and Group III ($p < 0.001$). In summary, the test revealed significant differences in CFU counts between the three groups across all time intervals (T0, T1, T2, and T3). Group I consistently showed the highest CFU counts compared to Groups II and III, with mean differences being statistically significant.

However, no significant differences were found between Group II and Group III at T0 and T1, while significant differences were observed at T2 and T3.

Table 2 Comparison of Mean CFUs b/w Different Time Intervals in Group I Using Repeated Measures of ANOVA Test

Time	N	Mean	SD	Min	Max	p-value
T0	10	29.90	4.82	23	39	<0.001*
T1	10	74.00	4.60	66	80	
T2	10	331.10	23.76	289	370	
T3	10	645.20	26.35	598	700	

*Statistically Significant

The table demonstrates the comparison of the mean CFUs in Group I across different time intervals. At time T0, Group I had a mean CFU of 29.90 ± 4.82, with values ranging from 23 to 39. At time T1, the mean CFU increased to 74.00 ± 4.60, with a range of 66 to 80. At time T2, the mean CFU further increased to 331.10 ± 23.76, with a range of 289 to 370. Finally, at time T3, the mean CFU reached 645.20 ± 26.35, with values ranging from 598 to 700. The test results indicated that there were statistically significant differences between the different time intervals at $p < 0.001$.

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Table 3 Multiple Comparison of Mean Difference in CFUs b/w Time Intervals in Group I Using Bonferroni's Post Hoc Test

(I) Time	(J) Time	Mean Diff. (I-J)	95% CI for Diff.		p-value
			Lower	Upper	
T0	T1	-44.10	-49.83	-38.37	<0.001*
	T2	-301.20	-326.45	-275.95	<0.001*
	T3	-615.30	-642.56	-588.04	<0.001*
T1	T2	-257.10	-283.96	-230.24	<0.001*
	T3	-571.20	-599.85	-542.55	<0.001*
T2	T3	-314.10	-346.95	-281.25	<0.001*

*Statistically Significant

Multiple comparisons of mean differences between time intervals in Group I using Bonferroni's post hoc Test showed significant differences. The mean CFUs at T0 showed significantly lower counts as compared to T1, with a mean difference of -44.10 (95% CI: -49.83 to -38.37), T2 with a mean difference of -301.20 (95% CI: -326.45 to -275.95), and T3 with a mean difference of -615.30 (95% CI: -642.56 to -588.04), which were statistically significant at $p < 0.001$, respectively. This was then followed by the T1 time interval, which showed significantly lower mean CFUs compared to T2 and T3, with mean differences of -257.10 (95% CI: -283.96 to -230.24) and -571.20 (95% CI: -599.85 to -542.55), respectively, showing statistical significance at $p < 0.001$. Finally, the mean difference between T2 and T3 was -314.10 (95% CI: -346.95 to -281.25), which also showed a statistically significant difference at $p < 0.001$.

This infers that CFU counts in Group I were significantly lowest at T0, followed by T1, T2, and highest at the T3 time interval.

Table 4 Comparison of Mean CFUs b/w Different Time Intervals in Group II Using Repeated Measures of ANOVA Test

Time	N	Mean	SD	Min	Max	p-value
T0	10	15.80	2.44	12	20	<0.001*
T1	10	2.60	1.35	1	5	
T2	10	222.00	21.81	189	265	
T3	10	518.40	29.12	489	576	

*Statistically Significant

The table demonstrates the comparison of the mean CFUs in Group II across different time intervals. At time T0, Group II had a mean CFU of 15.80 ± 2.44, with values ranging from 12 to 20. At time T1, the mean CFU decreased to 2.60 ± 1.35, with a range of 1 to 5. At time T2, the mean CFU significantly increased to 222.00 ± 21.81, with a range of 189 to 265. Finally, at time T3, the mean CFU further increased to 518.40 ± 29.12, with values ranging from 489 to 576. The test results indicated that there were statistically significant differences between the different time intervals at $p < 0.001$.

Table 5 Multiple Comparison of Mean Difference in CFUs b/w Time Intervals in Group II Using Bonferroni's Post Hoc Test

(I) Time	(J) Time	Mean Diff. (I-J)	95% CI for Diff.		p-value
			Lower	Upper	
T0	T1	13.20	10.69	15.71	<0.001*
	T2	-206.20	-230.25	-182.15	<0.001*
	T3	-502.60	-537.23	-467.97	<0.001*
T1	T2	-219.40	-244.01	-194.80	<0.001*
	T3	-515.80	-549.61	-481.99	<0.001*
T2	T3	-296.40	-337.57	-255.23	<0.001*

*Statistically Significant

Multiple comparisons of mean differences between time intervals in Group II using Bonferroni's post hoc Test showed significant differences. The mean CFUs at T0 were significantly higher compared to T1, with a mean difference of 13.20 (95% CI: 10.69 to 15.71), and significantly lower compared to T2, with a mean difference of -206.20 (95% CI: -230.25 to -182.15), and T3, with a mean difference of -502.60 (95% CI: -537.23 to -467.97), which were all statistically significant at $p < 0.001$, respectively.

This was then followed by the T1 time interval, which showed significantly lower mean CFUs compared to T2 and T3, with mean differences of -219.40 (95% CI: -244.01 to -194.80) and -515.80 (95% CI: -549.61 to -481.99), respectively, showing statistical significance at $p < 0.001$. Finally, the mean difference between T2 and T3 was -296.40 (95% CI: -337.57 to -255.23), which also showed a statistically significant difference at $p < 0.001$.

This infers that CFU counts in Group II were significantly highest at T3, followed by T2, T0, and least at T1 time interval.

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Table 6 Comparison of Mean CFUs b/w Different Time Intervals in Group III using Repeated Measures of ANOVA Test

Time	N	Mean	SD	Min	Max	p-value
T0	10	13.70	2.16	10	18	<0.001*
T1	10	4.60	1.51	2	7	
T2	10	38.10	6.30	30	50	
T3	10	137.50	9.66	120	152	

*Statistically Significant

The table demonstrates the comparison of the mean CFUs in Group III across different time intervals. At time T0, Group III had a mean CFU of 13.70 ± 2.16, with values ranging from 10 to 18. At time T1, the mean CFU decreased to 4.60 ± 1.51, with a range of 2 to 7. At time T2, the mean CFU increased to 38.10 ± 6.30, with a range of 30 to 50. Finally, at time T3, the mean CFU further increased to 137.50 ± 9.66, with values ranging from 120 to 152. The test results indicated that there were statistically significant differences between the different time intervals at $p < 0.001$.

Table 7 Multiple Comparison of Mean Difference in CFUs b/w Time Intervals in Group III Using Bonferroni's Post Hoc Test

(I) Time	(J) Time	Mean Diff. (I-J)	95% CI for Diff.		p-value
			Lower	Upper	
T0	T1	9.10	5.73	12.47	<0.001*
	T2	-24.40	-32.58	-16.22	<0.001*
	T3	-123.80	-135.19	-112.41	<0.001*
T1	T2	-33.50	-39.71	-27.30	<0.001*
	T3	-132.90	-144.22	-121.58	<0.001*
T2	T3	-99.40	-113.03	-85.77	<0.001*

*Statistically Significant

Multiple comparisons of mean differences between time intervals in Group III using Bonferroni's post hoc Test showed significant differences. The mean CFUs at T0 were significantly higher compared to T1, with a mean difference of 9.10 (95% CI: 5.73 to 12.47), and significantly lower compared to T2, with a mean difference of -24.40 (95% CI: -32.58 to -16.22), and T3, with a mean difference of -123.80 (95% CI: -135.19 to -112.41), which were all statistically significant at $p < 0.001$, respectively.

This was then followed by the T1 time interval, which showed significantly lower mean CFUs compared to T2 and T3, with mean differences of -33.50 (95% CI: -39.71 to -27.30) and -132.90 (95% CI: -144.22 to -121.58), respectively, showing statistical significance at $p < 0.001$. Finally, the mean difference between T2 and T3 was -99.40 (95% CI: -113.03 to -85.77), which also showed a statistically significant difference at $p < 0.001$.

This infers that CFU counts in Group III were significantly highest at T3, followed by T2, T0, and least at T1 time interval.

V. DISCUSSION

The risk of microbial contamination in the air of dental operatory settings has long been acknowledged, and this concern became even more pronounced during the COVID-19 pandemic. While routine disinfection procedures may eliminate a substantial portion of microorganisms, those that remain can rapidly multiply, accumulate, and potentially lead to cross-contamination of previously clean areas. Therefore, the present study was designed to compare the effectiveness of two fumigating agents in reducing the microbial aerosol load, expressed as colony-forming units (CFU), before and after ultrasonic scaling at various time intervals.[50]

A variety of commercially available fumigating agents undergo rigorous testing in controlled environments before they are introduced to the market. An ideal disinfectant should possess a broad antimicrobial spectrum, be non-irritating, minimally toxic, non-corrosive, and cost-effective.[51] In a review conducted by Stawarz-Janeczek et al., the currently available disinfectants recommended for use in dental practices to prevent SARS-CoV-2 transmission were discussed. Hydrogen peroxide demonstrates broad-spectrum activity against bacteria (including spores), mycobacteria, viruses, and fungi, and its effectiveness depends on both concentration and exposure time. Its mechanism of action includes the generation of reactive hydroxyl radicals, which damage nucleic acids (DNA and RNA), cause lipid peroxidation, and destabilize cell walls and membranes, ultimately resulting in cell lysis. Quaternary ammonium compounds (QACs) act as surfactants and are commonly used as low-level disinfectants. They exhibit bactericidal action, show particular effectiveness against gram-positive bacteria, and are virucidal against enveloped viruses such as HIV, but are ineffective against mycobacteria. Silver and its derivatives have also been used for many years as antimicrobial agents. Among these, silver salts such as silver sulfadiazine are commonly used, although silver nitrate and silver acetate continue to be utilized as well.

In the present study, two silver nitrate–based products, FUMISAN and SILVICIDE, were evaluated. These agents demonstrate activity against a wide range of microorganisms and are odorless, colorless, and non-corrosive in nature, making them suitable for aerial fumigation as well as surface and water disinfection. They also provide a residual

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bacteriostatic effect on treated surfaces while causing minimal irritation and exhibiting low toxicity. These agents were selected because they combine two active components, which are expected to exert a synergistic effect and thereby enhance their overall antimicrobial efficacy.[52-56]

The findings of the study revealed statistically significant differences in CFU counts among the three groups and across the different time intervals. In Group I, which consisted of ultrasonic scaling performed in a dental cabin without the use of any disinfectant, there was a steady and progressive increase in CFU levels from baseline (T0) through three hours after the procedure (T3).

In contrast, Group II, in which the dental cabin was disinfected with FUMISAN prior to ultrasonic scaling, demonstrated a reduction in CFU counts immediately following the procedure (T1). However, this was followed by a marked increase in microbial load at one hour (T2) and three hours (T3) post-scaling.

A similar trend was observed in Group III, where SILVICIDE was used as the disinfectant. There was an initial decrease in CFU levels immediately after scaling (T1), followed by significant increases at the one-hour (T2) and three-hour (T3) time points.

Overall, the study demonstrated that the combination of silver ions and hydrogen peroxide, as present in SILVICIDE, exhibited higher antimicrobial activity when compared to FUMISAN, which contains a combination of quaternary ammonium compounds and silver nitrate. The results also indicate that both disinfectants act rapidly, provide a residual effect on treated surfaces, and maintain antimicrobial activity for several hours after application.

There are some limitations of this study as we did not test for antimycobacterial and antiviral effect of any of the test agents. However, on subjective observation, Silvicide should be used with care keeping in mind the concentration of the agent as it caused burning sensation to eyes.

Future studies should combine various active and passive air sampling methods to evaluate microbial air contamination for a longer period of time after the completion of ultrasonic scaling. Incorporation of HEPA filters can also be considered as it may cause significant reduction of aerosols. In this study, the dental cabin in which the study was conducted was not well ventilated. Future studies can check for the significance of ventilation on the reducing the aerosols.

VI. CONCLUSION

The present study highlights the importance of using disinfectants in dental cabins to control CFU levels during and after ultrasonic scaling procedures. SILVICIDE demonstrated superior performance in maintaining lower CFU counts compared to FUMISAN, suggesting it may be a more effective disinfectant for reducing microbial contamination in dental environments.

VII. SUMMARY

The study highlights the importance of using disinfectants in dental cabins to control CFU levels during and after ultrasonic scaling procedures. SILVICIDE demonstrated superior performance in maintaining lower CFU counts compared to FUMISAN, suggesting it may be a more effective disinfectant for reducing microbial contamination in dental environments.

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