Original Article

Antimicrobial efficacy of chlorine di oxide vs. distilled water as ultrasonic coolants in reducing aerosol bacterial contamination: A clinical trial

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ABSTRACT

Background: Dental procedures such as ultrasonic scaling are known to generate aerosols that contain microorganisms, increasing the risk of cross-contamination and disease transmission, particularly in the context of the COVID-19 pandemic. The use of standard coolants such as distilled water (DW) in ultrasonic devices offers no antimicrobial benefit. Recent advances have proposed chlorine dioxide (ClO_2), an oxidative disinfectant, as a potential antimicrobial coolant. **Aim:** This study aimed to compare the effectiveness of DW and 1% stabilized ClO_2 solution (Freshchlor®) as ultrasonic scaler coolants in reducing microbial aerosol contamination during periodontal procedures. **Materials and Methods:** A total of 20 patients undergoing ultrasonic scaling were divided into two groups: Group 1 (DW) and Group 2 (ClO_2). Each patient underwent scaling in a controlled operatory environment. Agar plates were placed at a fixed location near the patient's chest to collect aerosolized bacteria during the procedure. The plates were incubated, and colony-forming units (CFUs) were recorded and statistically analyzed. **Result:** Group 2 (ClO_2) demonstrated a significantly lower CFU count (Mean: 84.0 ± 8.49) compared to Group 1 (DW) (Mean: 149.0 ± 20.19), with the difference being statistically highly significant ($P < 0.001$). **Conclusion:** Using ClO_2 as an ultrasonic coolant substantially reduces bacterial aerosol contamination compared to DW, supporting its application in routine dental procedures to improve infection control.

Key words: Aerosols, Chlorine dioxide, Colony-forming units, Contamination, Distilled water, Ultrasonic scaling

INTRODUCTION

The generation of aerosols during dental procedures presents a significant occupational health hazard. These aerosols may contain blood, saliva, bacteria, and viruses, which can be transmitted to both patients and dental professionals. Among the various procedures, ultrasonic scaling is particularly notorious for producing high volumes of fine aerosols that can remain suspended in the air for extended periods, increasing the risk of cross-infection.

The COVID-19 pandemic amplified concerns over airborne transmission, compelling the dental community to re-evaluate infection control protocols. Conventionally, distilled water (DW) has been the coolant of choice during ultrasonic scaling due to its availability and neutrality. However, DW lacks any antimicrobial property, which means it does not contribute to reducing the bacterial load generated during the procedure. This is consistent with findings by Kinane *et al.*, who showed that water-based cooling resulted in widespread bacterial dispersion during periodontal therapy.[1]

In contrast, chlorine dioxide (ClO_2), a stabilized aqueous solution known for its oxidative bactericidal and virucidal properties, has emerged as a promising alternative. It disrupts microbial metabolism and neutralizes toxins, actively reducing microbial populations in real time during the procedure. Retamal-Valdes *et al.*, reported significantly reduced bacterial counts with ClO_2 mouthrinses.[2]

Unlike preprocedural mouthrinses that act for a limited period, ClO_2 used as a coolant ensures continuous antimicrobial exposure, offering extended benefit. Jawade *et al.* and Khattri *et al.* have also reported notable CFU reduction when ClO_2 was used as an irrigant or rinse.[3,4] In addition to pre-procedural rinsing and antimicrobial coolants, other adjunctive measures such as subgingival irrigation and high-volume suction devices have been explored to control microbial dispersion. Greenstein emphasized the potential role of supragingival and subgingival irrigation in reducing bacterial counts during periodontal therapy.[5] Furthermore, early studies by Bentley *et al.*, Rivera-Hidalgo *et al.*, and Leggat and Kedjarune provided foundational evidence of aerosol contamination risks in dental clinics, highlighting the urgent need for effective

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control strategies such as antimicrobial coolants.[6-8] With limited comparative data between ClO_2 and DW as coolants, this study aims to evaluate their efficacy in reducing aerosol contamination during ultrasonic scaling.

MATERIALS AND METHODS

This comparative study was conducted on 20 patients who were randomly selected from the outpatient department of periodontology and implantology. The sample size was calculated using G Power software, and ethical clearance was obtained from the Institutional Ethical Committee (IEC/246/2023/10). Written informed consent was obtained from all participants.

The inclusion criteria for this study comprised patients between the ages of 18 and 60 years who were seeking periodontal care. Patients were excluded if they had any systemic conditions such as diabetes mellitus or cardiovascular disorders, were currently on antibiotics or analgesics, had a history of tobacco use, had undergone periodontal therapy within the past 6 months, were pregnant or nursing females, or had known allergies to ClO_2.

Using a randomization table, each of the three groups, which had 10 individuals each, was assigned to all of the subjects.

Two groups comprising all the subjects were formed:

- Group 1: DW as a coolant.
- Group 2: 1% aqueous stabilized ClO_2 (Freshchlor®), is diluted in 1:1 ratio in 1 L water to prepare the coolant.

The working cubicle was fumigated to maintain a sterile, clean environment before the start of the therapy.

Two agar plates were used for each patient. At the baseline, one nutrient agar plate was placed in a fumigated chamber for 20 min before the ultrasonic scaling procedure [Figure 1].

In addition, a second plate was also placed 20 min into the scaling procedure, 40 cm from the working area and close to the patient's chest [Figure 2].

The treatments were all administered in the same closed operatory room. Using the same patient positioning and a standardized dental chair, the oral prophylaxis was performed. To keep the operator room aerosol-free, the same dentist handled every treatment process and treated only one patient in a single day.

It was performed using a piezoelectric ultrasonic scaler set at a consistent frequency, with the coolant pressure maintained at a constant level throughout the procedure. In addition, a motorized suction device was utilized to assist in removing debris throughout the procedure. After the treatment procedure, the agar plates were sent for the microbiological analysis carefully.

The plates were then incubated at 37°C for 48 h. Subsequently, a microbiologist conducted a colony counting procedure using a colony counter device.

Statistical analysis

The data were entered into a Microsoft Excel spreadsheet and imported into the statistical package for the social sciences version 23 for statistical analysis. Qualitative data were presented in frequency and percentage, and quantitative data were presented in mean and standard deviation. One-way Analysis of Variance test was performed to find a significant difference in mean CFU during treatment between the groups. Statistical significance was defined as a $P < 0.05$ and statistical high significance as a $P < 0.001$.

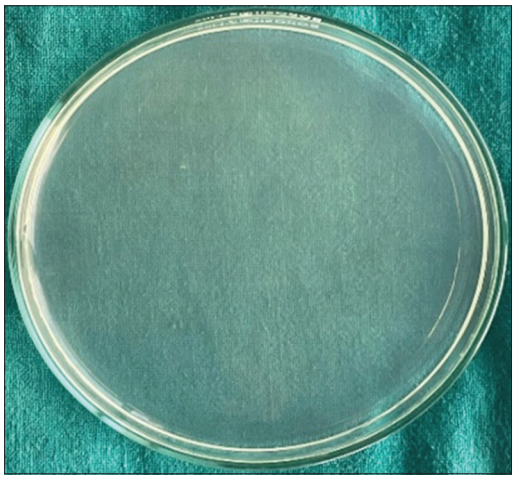

Figure 1: Baseline nutrient agar plate after fumigation

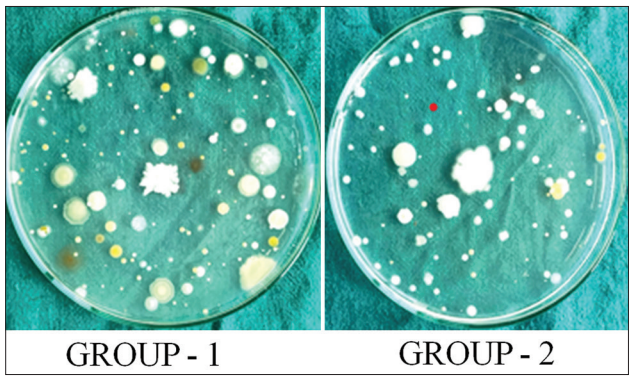

Figure 2: Colony-forming units of all three groups on nutrient agar plates

RESULT

Table 1 presents the demographic characteristics of the participants in both study groups. The mean age of participants in group 1 was 27.5 ± 6.28 years, while that of group 2 was 27.1 ± 5.34 years. The difference in age distribution between the two groups was statistically not significant ($P = 0.879$), indicating age was well matched across the groups. In terms of gender distribution, group 1 comprised 7 males and 3 females, whereas group 2 had 6 males and 4 females. The gender distribution was also found to be statistically non-significant ($P = 0.982$).

Table 2 outlines the comparison of mean CFUs collected during ultrasonic scaling between group 1 and group 2. Group 1 (DW) showed a mean CFU count of 149.0 ± 20.19. Group 2 (ClO_2) demonstrated a mean CFU count of 84.0 ± 8.49. The analysis

Table 1: Demographic data

Demographic data	Group-1 (distilled water) (*n*=10)	Group-2 (Freshclor) (*n*=10)	*P*-value
Age in years (Mean±SD)	27.5±6.28	27.1±5.34	0.879#
Male/female	7/3	6/4	0.982#

#statistically not significant. *P*>0.05; NS, SD: Standard deviation

Table 2: Comparison of mean colony forming unit in between group-1(distilled water) and group-2 (freshclor) during treatment

Groups	*N*	Colony forming unit During treatment		F-value	*P*-value
		Mean	Standard deviation		
Group-1 (distilled water)	10	149.0	20.19	139.52	<0.001**
Group-2 (Freshclor)	10	84.0	8.49		

P>0.05; NS, ** *P*<0.001; highly significant. SD: Standard deviation

of variance revealed a statistically highly significant difference between the two groups (F = 139.52; $P < 0.001$).

DISCUSSION

The results of the present study clearly highlight the superior efficacy of ClO_2 over DW in reducing bacterial aerosol contamination during ultrasonic scaling. The mean CFU count in the ClO_2 group was significantly lower than that in the DW group, with a highly significant *P*-value (<0.001). These findings are in line with previous research, which has identified ClO_2 as a potent antimicrobial agent suitable for clinical use in dental settings.

While DW serves as a neutral coolant, it lacks antimicrobial properties. Thus, when used during ultrasonic debridement, it merely facilitates heat dissipation without contributing to bacterial control. On the contrary, it may inadvertently support the aerosolization of oral flora, increasing the microbial burden in the operatory environment. This reinforces earlier conclusions by Kinane *et al.*, who found that scaling with water resulted in considerable bacterial dissemination, increasing the potential for transient bacteremia and aerosol-based contamination.[1]

ClO_2, in contrast, functions as a potent oxidizing agent that disrupts microbial metabolic pathways by denaturing proteins and damaging cell membranes. It has been shown to be effective against Gram-positive and Gram-negative bacteria, as well as fungi and viruses. Retamal-Valdes *et al.*, demonstrated that pre-procedural rinsing with ClO_2 led to a notable reduction in airborne CFUs, reinforcing its use in reducing microbial aerosols.[2] Although most prior studies focused on ClO_2 as a mouth rinse, its use as a continuous coolant provides extended antimicrobial contact time during the procedure, further enhancing its efficacy.

A study by Jawade *et al.*, compared different ultrasonic coolants and also found that antimicrobial agents, including ClO_2, significantly lowered CFU levels compared to water, underscoring their importance in aerosol infection control.[3] Similarly, Khattri *et al.*, observed reduced bacterial contamination when ClO_2 was used as a pre-procedural rinse compared to no rinse at all.[4] These findings align with the results of the current study, suggesting that ClO_2 may be an effective replacement for water in ultrasonic scalers.

Furthermore, the use of antimicrobial coolants addresses several limitations associated with preprocedural mouth rinses, such as variability in rinsing time and compliance. Studies such as those by Gupta *et al.*, and Logothetis and Martinez-Welles emphasized that while mouth rinses reduce initial microbial load, their effects are short-lived.[9,10] In contrast, ClO_2 in coolant form provides continuous irrigation and disinfection, ensuring a more consistent and prolonged antimicrobial effect during the procedure.

Importantly, ClO_2 when used at low concentrations has no reported cytotoxic effects. Its safety profile, coupled with its efficacy, makes it suitable for integration into routine dental practice, especially for procedures that inherently generate aerosols, such as ultrasonic scaling, air polishing, and restorative preparations.

Therefore, the findings of this study and those of previous research collectively emphasize the clinical advantage of using ClO_2 over DW in minimizing the microbial load in aerosols, thereby reducing the potential for nosocomial infections and occupational exposure in dental settings.

CONCLUSION

Within the limitations of this study, it can be concluded that ClO_2 is significantly more effective than DW in reducing bacterial aerosol contamination during ultrasonic scaling. Its inclusion as an ultrasonic coolant offers a practical, efficient, and safe method to enhance infection control protocols in dental operatory settings. Given its advantages, ClO_2 could be considered a preferred alternative to DW, particularly in the post-COVID-19 era, where heightened infection control is paramount.

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