Original Article

Evaluation of Aerosol Contamination During Debonding Procedures

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Abstract: The aim of this study was to show how the aerosol generated by the use of an air turbine handpiece during debonding procedures increases the potential risk factor for the distribution of infectious agents. A second aim of the study was to evaluate the effectiveness of a preprocedural chlorhexidine mouth rinse in reducing the number of colony forming units (CFU) found in aerosol samples. Blood agar plates were attached to the face shields and the dental chair table and were used for collecting the aerosol samples. In the first part of the study, 260 samples were collected for the baseline group in an empty room, 36 samples were collected for the control group (C), in which the orthodontist, dental assistant, and the patient were in the operatory room, and 42 samples were collected for the debonding group (DB). The microbiologic analysis showed significant differences between the baseline group and the control group ($P < .05$). Furthermore, aerosol contamination increased significantly during the debonding procedure when compared with the control group ($P < .01$). In the second part of the study, an air turbine handpiece was used to remove excess adhesive from the tooth surface on one side of the mouth and air samples were collected. The patients then were instructed to rinse their mouths with 0.2% chlorhexidine gluconate for 1 minute, and the orthodontist worked on the other side of the mouth and the air sampling was repeated. An insignificant reduction was found in the number of colony forming units following the chlorhexidine mouth rinse. Results of this study indicated that orthodontists are exposed to high levels of aerosol generation and contamination during the debonding procedure, and preprocedural chlorhexidine gluconate mouth rinse appears to be ineffective in decreasing the exposure to infectious agents. Therefore, barrier equipment should be used to prevent aerosol contamination. (*Angle Orthod* 2001;71:299–306.)

Key Words: Mouth rinses; Spatter; Aerosol reduction device (ARD); Cross-contamination; Infectious agents

INTRODUCTION

The humidity and temperature of the oral cavity create a wide range of habitats with different environmental conditions and provide an ideal media for growth and colonization of microorganisms.[1] Oral flora comprise various groups of microorganisms including bacteria, fungi, mycoplasma, protozoa, and viruses. It has been reported that at least 200 different kinds of bacteria reside in the oral cavity,[2] that 1 g of gingival crevicular fluid contains 150 billion microorganisms, and that 6 billion microorganisms can be found in 1 ml of saliva.[3] Dental health professionals, because of repeated exposures to these microorganisms, are at high risk for developing infectious diseases.[4,5]

Transmission of microorganisms from person to person may occur by direct contact with contaminated tissues or instruments or by aerosols containing infectious agents.[2] Aerosols are defined as suspensions of liquid and/or solid particles in the air generated by coughing, sneezing, or any other act that expels oral fluids into the air.[2,5,6] Although there are several different definitions in the literature, aerosols containing particles more than 50 μm in diameter are referred to as spatter, while particles measuring less than 50 μm are called droplet nuclei.[6,7] Because gravitational pull causes spatter aerosols to settle very quickly on surfaces, they are less likely to carry microorganisms that induce infection. Droplet nuclei, however, remain suspended in the air for many hours and can infect persons by direct inhalation and penetration deep into the lungs.[2] Larger 10–15-μm droplet nuclei particles are closely related to upper respiratory infections, while smaller 0.5–5-μm droplet nu-

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clei can accumulate in the lower respiratory tract and may cause viral respiratory infections.[2,7,8]

The aerosol production from the use of air turbines, ultrasonic and sonic scalers, and air polishers is well documented in the dental literature.[6–9] These instruments require a water spray to cool the working tip and to prevent heat production. A water spray is also used to lavage the working area in order to increase the operator's vision. As soon as this water spray is emitted from the handpiece of the instrument, it can mix with the patient's saliva and any blood present to form a potentially pathogenic aerosol.[9]

During routine orthodontic procedures such as wire insertion, ligature tying, attaching the brackets to the tooth surfaces, etc, aerosol generation is usually not expected since no high-speed instruments are used. However, at the termination therapy, the attachments and the remaining adhesive resin must be removed from the teeth without producing any damage to the tooth surface. This can be done either by using bond-removing pliers or scalars or by using a suitable bur and contra-angle. Removal of residual excess adhesive from the tooth surface after bracket removal often requires the use of a suitable dome-tapered tungsten carbide bur in a contra-angle handpiece operated at a speed of approximately 30,000 rpm. The tip must be water cooled to prevent permanent damage or necrosis of the dental pulp. This water spray may create an aerosol spray around the operatory area, threatening the orthodontist, the dental assistant, and the patient with possible infection risk. It has been recommended that water cooling should be discontinued when the last remnants of adhesive are removed because it lessens the contrast of the adhesive and tooth surface.[10] Aerosol generation is also expected during orthodontic therapy while stripping teeth, trimming retainers,[11] or with air-powder polishers.[12]

This study consisted of 2 parts. The aim of the first part of the study was to evaluate the amount of aerosol contamination during the removal of excessive adhesive bonding materials with a handpiece in orthodontic patients and to identify the microorganisms present in the aerosol spray. The second part of the study aimed to clarify the clinical effects of a preprocedural chlorhexidine mouthwash on the amount of aerosol generation.

MATERIALS AND METHODS

Study I

A group of 14 patients composed of 8 boys and 6 girls who were ready for the debonding volunteered for the experimental group (debonding; DB). All subjects had been treated with full-banded edgewise nonextraction treatment with bands on their molars and brackets on the rest of the teeth. The control group (C) consisted of an additional 12 patients, composed of 3 boys and 9 girls.

The mean age of the patients in the debonding group (DB) was 12.1 years, with a range of 11–13 years. In the control group (C), the mean age of the patients was 12.4 years, with a range of 10–15 years. To participate in the study, the subjects had to meet the following inclusion criteria: no signs of respiratory infection, rheumatic heart disease, or any other systemic disease requiring antibiotic medication; no current anticoagulant or steroid therapy; no periodontal therapy including scaling, root planning, or prophylaxis during the past 6 months, and the presence of a mean plaque index and gingival index ≤ 1.5.

The orthodontist and his assistant wore sterilized surgical gloves, masks, and face shields during all of the study procedures. To prevent any possibility of mistake, all procedures were done in the same room, which had an air-exchange rate of 10 times per hour. Water for handpieces was supplied from external water containers at the dental units and not from the municipal water supply systems. These containers were sterilized and refilled with sterile water for every patient. This eliminated any possible microbial contamination from the dental waterlines. The patients were scheduled with the first patient at an early morning hour to ensure the lowest rate of air turbulence.

Collecting baseline samples

To collect baseline bacterial samples in the unoccupied and closed room, 10 blood agar plates were placed on various surfaces around the dental chair (dental chair, chair table, light, suction area etc) before the orthodontist, dental assistant and the patient entered into the room. All blood agar plates were less than 30 cm from the dental chair. Blood agar plates were chosen for their nonselective characteristics and ability to promote the growth of many aerobic organisms. The plates were exposed for 30 minutes during which nobody entered the room. A 30-minute interval has been reported as an adequate time to collect pretreatment baseline air samples.[5]

There were 12 patients in the control group (C) and 14 patients in the debonding group (DB). Therefore, this procedure was repeated for 26 days and 260 blood agar samples were collected.

Control air samples

After an orthodontist, the orthodontic assistant, and a patient from the control group entered the room, 2 blood agar plates were positioned on the orthodontist's and assistant's face shields and 1 plate was positioned on the dental unit table (30 cm away from the working area) (Figure 1). The plates were opened and the orthodontist worked for 5 minutes in the patient's mouth (relying on the guidelines of 4-handed dentistry[13]), doing routine orthodontic procedures where the use of high-speed handpieces was not required. The assistant used slow-speed evacuation to remove the saliva of the patient. After 5 minutes, the procedure was terminated and the patient, the orthodontist, and the assistant remained stationery for an additional 25 minutes during

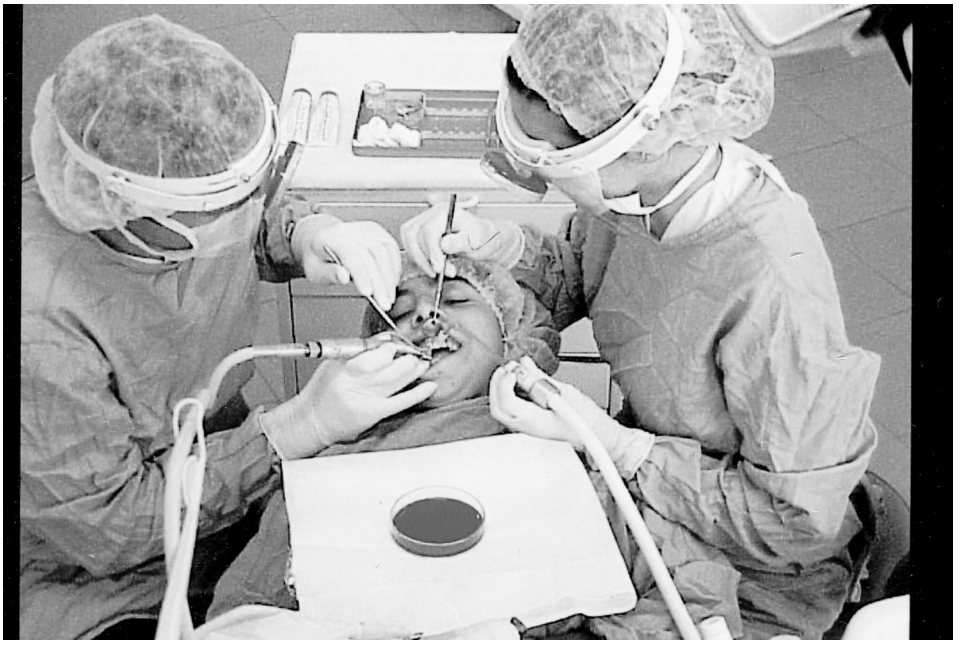


FIGURE 1. Microbial sampling technique used during the routine orthodontic procedures during the debonding procedure.

which the blood agar plates were exposed to the air for 30 minutes (5 minutes + 25 minutes). Then the plates were covered and color coded. This procedure was repeated for every patient on different days. Thirty-six blood agar samples were collected for the control group.

Debonding group

After all braces were removed with bracket-removing pliers (Dentaurum, Inc; 003-349) in another room, the patient was directed to the experimental room. Again, the orthodontist and the assistant were seated and positioned as described for the control group[13] (Figure 1). The blood agar plates were also adjusted on the face shields and on the dental chair table. The plates were opened and the dentist used a tungsten carbide bur on a handpiece at 30,000 rpm with water cooling to remove the excess adhesive material left on the right side of the upper and the lower dental arches. As in the control group, the assistant used slow-speed evacuation with a working time limited to 5 minutes. After an additional 25 minutes of remaining stationary, the plates were covered and color coded. Forty-two blood agar samples were collected for the DB group.

Study II

The patients were selected for study II using the same criteria as were used in study I. The volunteer sample consisted of 12 patients, 7 boys and 5 girls, with a mean age of 11.5 and a range of 10–15 years.

Two separate rooms were used. Blood agar plates were positioned on the dentist's and assistant's face shields and on the dental chair table. A split-mouth design was used to allow each patient to serve as his or her own control. Following the removal of the braces with bracket-removing pliers, the plates were opened. The excess adhesive material left on the teeth was removed on the right side of the patient's mouth with a tungsten carbide bur on a handpiece operated at 30,000 rpm for 5 minutes (Figure 1). After an additional 25 minutes of remaining stationary, the plates were covered.

Then the patient rinsed his/her mouth with 15 ml of 0.2% chlorhexidine gluconate mouthwash for 1 minute and was immediately directed to the other room. The room was changed to eliminate the contamination of the aerosol sample that had already been created in the first room. The same clinical procedure was performed for the other side of the mouth (left side) with blood agar plates on the face shields and on the unit table. After 5 minutes of working time and 25 minutes of waiting for air sampling, the plates were covered and color coded. A total of 72 blood agar samples were collected for study II.

Microbiologic analysis

The color-coded agar plates were incubated for 3 days at 37°C. One microbiologist, blinded to the treatment groups, counted the number of colony forming units (CFUs) on each plate using a Quebe Colony Counter. The microorganisms were identified macroscopically and microscopically. Further identification of the species was determined using the following tests:

(a) catalase and coagulase tests for *Staphylococcus*,
(b) hemolyte characteristics and bacitrocine and optocine tests for *Streptococcus*,

TABLE 1. The Greatest Statistically Significant Increase in the Number of Colony Forming Units (CFUs) Was Measured for the Debonding Group; the Data Also Show That the Presence of a Person in an Operatory Room, Even When Not Working With a Dental Handpiece, May Increase the Number of Bacteria in a Dental Aerosol

Empty Room (Baseline)		3 Persons in Room (Control)		Debonding (DB)		Significance	
						Baseline vs Control	Control vs Debonding
Mean	SD	Mean	SD	Mean	SD		
6.70	8.05	11.20	5.88	60.43	56.56	0.0149*	0.0016**

* $P < .05$.
** $P < .01$.

(c) oxidase activity, carbohydrate fermentation test, and IMVIC tests for Gr(−) bacilli.

Statistical analysis

The data were analyzed using an analysis of variance and Wilcoxon matched pairs-ranks test. The computer program SPSS for Windows (version 8.0) was used in the analysis of the data, and significance was set at the $P < .05$ level. The baseline group was compared with the control group using analysis of variance. The control group also was compared with the debonding group using analysis of variance. The individual changes between before and after the chlorhexidine rinse and for the total amount was compared using the Wilcoxon matched pairs signed-ranks test.

RESULTS

Study I

The mean number of CFUs was significantly increased ($P < .05$) during the routine orthodontic procedures (C) compared with the baseline, empty-room samples (11.2 ± 5.88 CFUs vs 6.7 ± 8.05 CFUs) (Table 1). The mean number of CFUs was significantly greater ($P < .01$) in the DB group, in which a tungsten carbide bur on a handpiece at a speed of 30,000 rpm was used to remove excessive adhesive, compared with the control group (60.43 ± 56.56 CFUs vs 11.2 ± 5.88 CFUs) (Table 1).

Study II

The mean number of CFUs, both in the individual counts and in the total amount, was not significantly different with or without the use of a chlorhexidine rinse ($P > .05$) (Table 2).

TABLE 2. Individual and Total Mean Number of Colony Forming Units (CFUs) Generated in Aerosol Samples; No Significant Reduction in the Mean Values of CFUs was Observed After Rinsing with Chlorhexidine Gluconate

	Chlorhexidine				
	Before		After		Significance*
	Mean	SD	Mean	SD	
Orthodontist	33.31	21.80	30.08	18.43	0.1698
Assistant	28.31	25.16	23.00	27.70	0.9721
Dental chair/table	38.69	26.55	30.85	34.46	0.4561
Total	100.31	48.94	83.92	65.23	0.2094

* $P < .05$.

DISCUSSION

In the dental profession, the aerosol generated by the use of a high-speed rotary handpiece with water spray causes an infection control problem that threatens the clinician, the assistant, and the patient. It has been shown that an aerosol cloud is always contaminated with blood,[8] and dental nurses are subject to more aerosol-related infections including nasal irritation, conjunctivitis, coughing, and skin infections compared with other service nurses.[14] Belting et al[15] showed that *Mycobacterium tuberculosis* contaminates the entire dental suite when treating patients with a previous tuberculosis history.

The Occupational Safety and Health Administration (OSHA), The Centers for Disease Control and Prevention (CDC), and the American Dental Association (ADA) all have regulations and specific protocols for infection control against blood-borne pathogens.[16–18] Their recommendations include protocols in the areas of patient screening, aseptic technique, surface disinfections, professionalism, lab asepsis, instrument sterilization, and equipment asepsis.[19]

The results of our study showed that, after 5 minutes of working time with a high-speed handpiece removing excess adhesive material, the environmental aerosol significantly increased compared with baseline and control values (Figure 2). This amount of aerosol must be considered as carrying a possible blood-borne pathogen and the recommended guidelines must be followed to protect the dental staff. These guidelines include the use of high-speed evacuation and personal barrier protection. High-speed evacuation is possible with the use of surgical high-power suction instruments or an aerosol reduction device (ARD). Although an ARD has been shown to be effective in reducing aerosol contamination,[5] the use of the system is limited to ultrasonic scalers and air polishers and cannot be applied to air turbines that are used to remove the excess adhesive material.

The protocols also call for the use of personal barrier equipment including gloves, facemasks, face shields, and eye shields. In our study, we have shown that a consider-

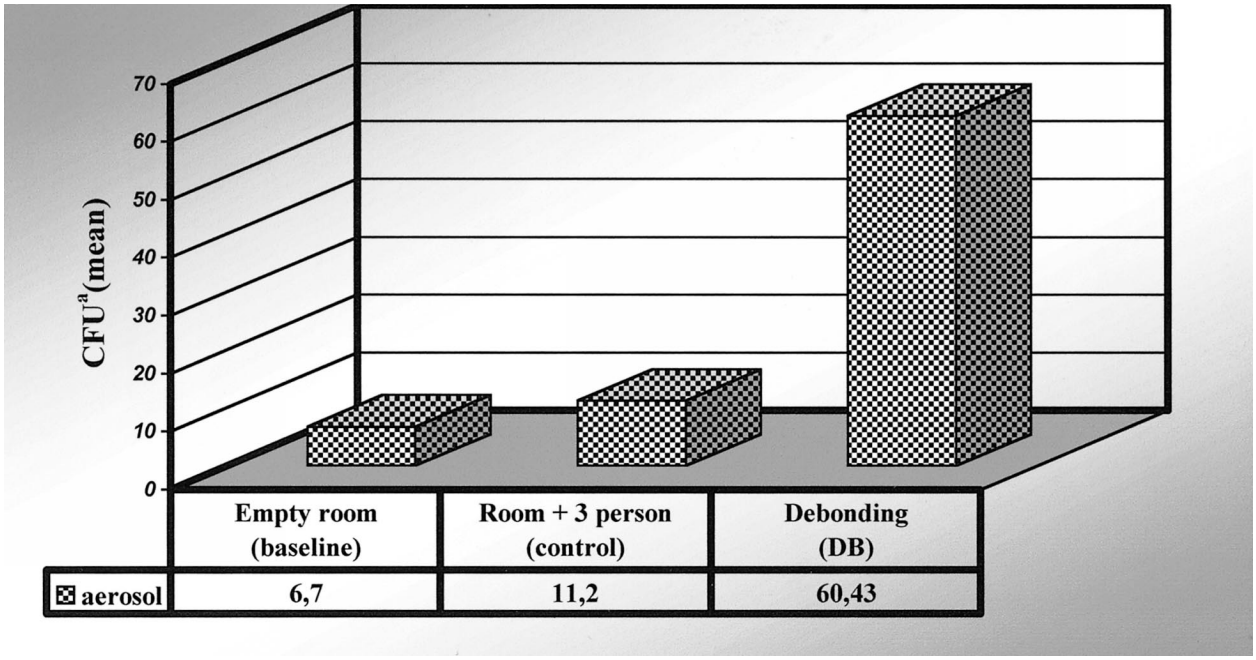


FIGURE 2. Note that, in the debonding group, the amount of aerosol generated many more CFUs (colony forming units) than did the baseline group and the control group. [a], CFU.

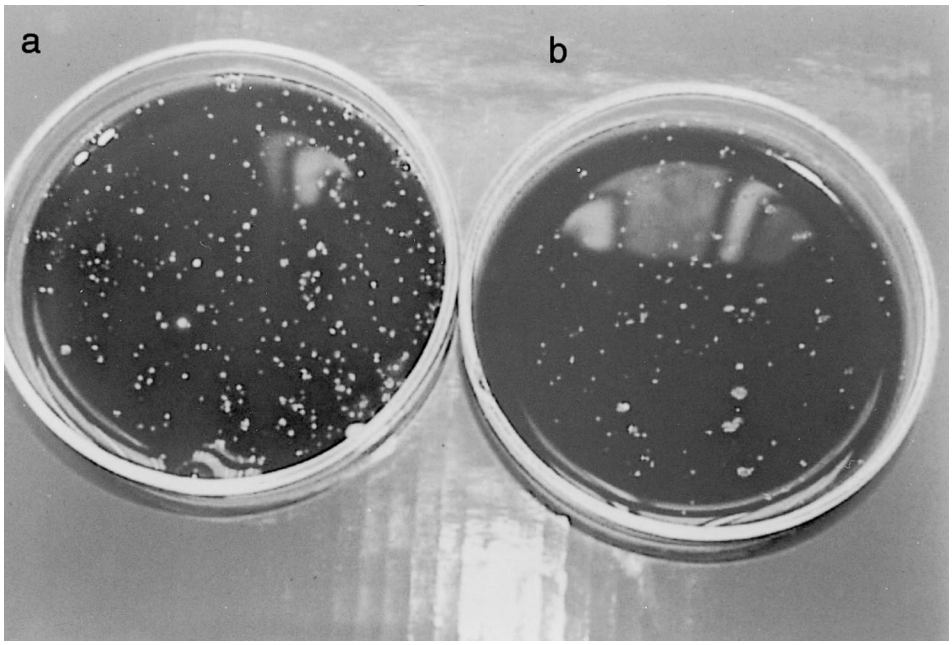
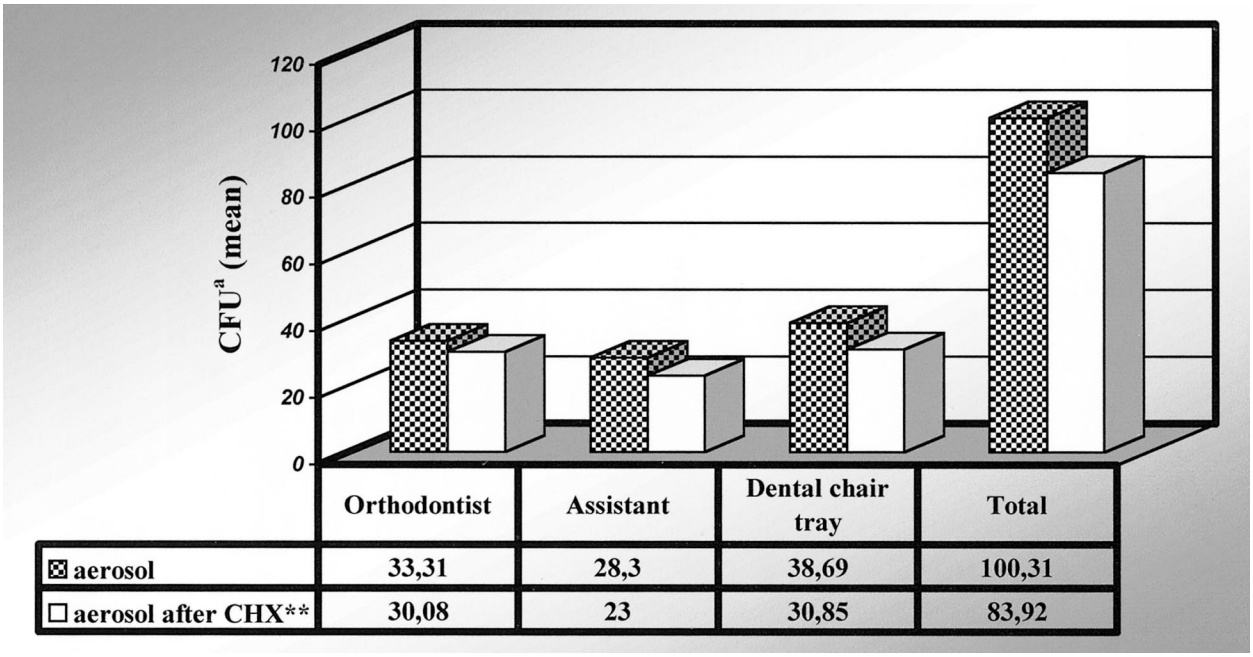


FIGURE 3. (a) A considerable number of microorganisms were found on the blood agar plate, which was fixed on the clinician's face shield. (b) Following rinsing with 0.2% chlorhexidine gluconate, a slight reduction in the amount of microorganisms can be observed.

able amount of microorganisms were found on the blood agar plate fixed on the orthodontist's face shield (Figure 3). This shows that face shields are effective in protecting the dentist from aerosol contamination. However, Bentley et al[20] have reported that face shields alone are not sufficient to protect the clinician. They recommended that eyeglasses and facemasks covering the nose and the mouth be used together with the face shield. The authors also advise clinicians to protect their necks and arms since wounds on these regions can easily be contaminated with aerosol spray.

Drake[21] recommended that dental professionals and patients also use eyewear during any procedure that could cause eye injury from debris or chemical agents. Because of their limited vascularity and diminished immune capac-



	Orthodontist	Assistant	Dental chair tray	Total
☒ aerosol	33,31	28,3	38,69	100,31
☐ aerosol after CHX**	30,08	23	30,85	83,92

FIGURE 4. The orthodontist, dental assistant, and the dental chair were exposed to similar amounts of microorganisms due to aerosol generation. After rinsing with chlorhexidine gluconate, no significant decrease was found for the mean value of microorganisms found in aerosol samples. [a]CFU (colony forming unit); **, CHX (chlorhexidine gluconate).

ities, the eyes are susceptible to physical and microbial injury, and conjunctivitis can develop from microbial contaminants in the aerosolized droplets.[13]

Miller[9] reported that 15–83% of 0.06–2.5-μm-sized plasma aerosol particles could pass through the filter media of 9 makes of surgical masks used by dental professionals for protection from occupational infection. Therefore, the use of multilayered, preformed, cup-style facemasks instead of conventional, single-layered masks is recommended.[20]

On the other hand, McCarthy et al[22] have reported that orthodontists were significantly less likely to use masks or protective eyewear or to sterilize handpieces. The authors pointed out that orthodontists may think that they are less exposed to aerosols than general dentists. Although the preponderance of orthodontic patients are adolescents who are considered to be less likely to carry infections, the fact is that 1 in 4 HIV infections occurs in persons under 20 years of age[23] and the increasing number of adults seeking orthodontic therapy should alert the clinician to use barrier protection.

Another method of infection control is the use of preprocedural mouth rinses. Although many studies have been reported evaluating the effectiveness of preprocedural mouth rinses, chlorhexidine glucanate (CHG) has received most of the attention in the literature.[24,25] In this study, although no statistical significance was noted, it was found that a preprocedural mouth rinse with CHG did lower slightly the total amount of bacteria in the aerosol spray (Figure 4). This finding agrees with Logothetis and Martinez-Welles,[24] who have shown that CHG pretreatment rinse was effective in reducing bacterial aerosol contamination with the use of an air polisher. Tzukert et al[26] reported that preprocedural rinses with CHG prior to dental treatments lessen the potential risk of bacteremia by decreasing the total microbial concentration in patients with rheumatic heart disease or prosthetic heart valves. Weeks et al[27] noted that the salivary bacterial population was reduced significantly within 1 minute after a rinse with CHG and that the reduction persisted for 30 minutes. However, the long-term use of CHG does have some local, reversible side effects such as staining of the teeth and tongue and impairment of taste perception. These factors plus the bitter taste of the rinse[25] may limit the routine use of CHG before dental procedures.

The most common microorganisms found in the aerosol spray were *Streptococcus*, diphtheroids, *Neisseria*, and *Staphylococcus* both with and without the use of CHG. The evidence of where these microorganisms grow and their associated surroundings can give some evidence of why they were the most common in the aerosol samples. *Streptococcus* is the main cause of bacterial endocarditis in compromised patients, and the normal habitat is the human upper respiratory tract and skin.[2] Similarly, diphtheroids are normal inhabitants of the skin and conjunctiva, and they are the agents of upper respiratory tract infections.[2] Commensal *Neisseria* are mostly found in the oral specimens contaminated with saliva or mucosa, and they are usually nonpathogenic.[2] *Staphylococcus* is a normal commensal on the skin surface and anterior nares, which has the characteristic of an opportunist pathogen and may cause catheter-

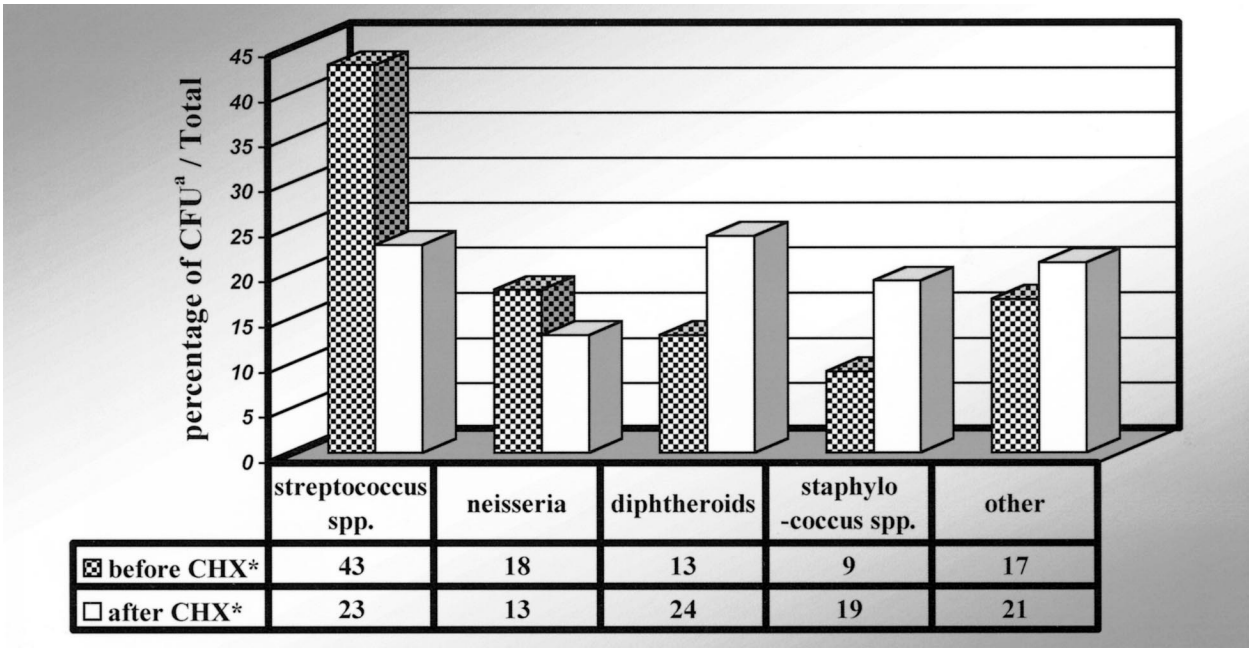


FIGURE 5. Comparisons of the changes in the percentages of the microorganisms in the aerosol samples following rinsing with chlorhexidine gluconate. The percentages were calculated as the mean colony forming units of each microorganism/total number of colony forming units × 100. [a]CFU (colony forming unit). *, CHX (chlorhexidine gluconate).

related sepsis and infection of artificial joints.[2] One possible reason that this bacteria was one of the most common in this study might be that water from the air turbine contacts the patient's lips and cheeks and disperses from the skin surface.

The use of a chlorhexidine rinse did not appear to be effective in reducing the total bacterial count, whereas microbiological evaluation showed a certain deviation in the pattern of bacterial colonization after rinsing with chlorhexidine (Figure 5). Before rinsing with chlorhexidine, 43% of the total aerosol sample consisted of *Streptococcus.* Following rinsing, this percentage decreased to 23%. This result, documenting the significant effectiveness of the chlorhexidine at reducing the number of *Streptococcus,* is consistent with the findings of Twetman et al,[28,29] Achong et al,[30] and Steinberg et al.[31] However, the percentages of the *Staphylococcus, Neisseria,* diphtheroids, and the others increased significantly. This phenomenon can be explained by the fact that the *Streptococcus* are more sensitive to chlorhexidine and the multiplication of the *Streptococcus* is slower than the saprophyte-commensal bacteria like *Staphylococcus,* diphtheroids, and *Neisseria.*[32,33]

One limitation of this study was the inability to isolate certain strict anaerobic bacteria or viruses in the aerosol spray. Although there is no evidence of hepatitis B or human immunodeficiency virus (HIV) transmission through inhaling aerosols, it is not unlikely that aerosol spray might contain hepatitis B, hepatitis C, herpes simplex, or HIV viruses when the blood is aerosolized and incorporated into the aerosol of the cooling water. Furthermore, inhalation is the major transmission route of the viruses of measles and mumps along with respiratory viruses such as influenza virus, rhinovirus, and adenovirus, and all of these viruses might also be present in the aerosol.[2]

Finally, the results of this study show that the use of high-speed air turbines with coolant water during the removal of adhesive material significantly increases the amount of aerosol contamination in and around the operatory area. Moreover, the level of viable bacteria cannot be reduced significantly by preprocedural CHG mouth rinse. Further studies are needed to clarify the exact composition of the aerosol spray and to determine the ideal methods of an infection-control regimen.

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