

BACTERIOLOGICAL EVALUATION OF A NEW AIR TURBINE HANDPIECE FOR PREVENTING CROSS-CONTAMINATION IN DENTAL PROCEDURES

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ABSTRACT

An autoclavable air turbine handpiece, Air Flushing Clean System (AFCS) (Osada Electric Co., Ltd., Tokyo, Japan) was developed for use in dentistry with the objective of reducing cross-contamination. Its potential for bacterial contamination was investigated *in vitro* using two bacterial strains (*Streptococcus mutans* ATCC 25175 and *Staphylococcus aureus* FDA 209 P). In theory, this device should prevent cross-contamination of the internal water and air lines of the handpiece, by maintaining an internal positive pressure even after the turbine is stopped. In the present study, this AFCS device was found to reduce the bacterial contamination within the air turbine handpiece more effectively than the conventional handpiece used according to accepted protocol. The reduction of such contamination by the AFCS is in keeping with the recent objective of the American Dental Association to reduce cross-contamination during dental procedures.

Key Words: Dental unit, Bacteria, Cross-infection, Decontamination, Suckback

INTRODUCTION

The air turbine dental handpiece (HP) and dental unit were developed in the 1950s to protect the pulp tissue from thermal damage. Water-cooled spray systems were subsequently developed. However, when the turbine and spray were turned off, the expanded plastic waterline gradually contracted and water dripped from the HP and soiled the patient's clothing. Currently, most manufacturers attach a piston-like retraction system which draws back a certain amount of water and air, containing microorganisms, into the unit. The internal and external regions of the conventional-type HP, therefore, are at risk for contamination with bacteria, saliva, blood, dental plaque, and pus. The design of the conventional HP allows a small amount of air to be sucked back,¹⁾ then to be released, causing contamination. The contamination of the dental unit water supply (DUWS) may be due to the aspiration of exogenous microorganisms into the unit HP, or to direct contamination by the operator.²⁾ A recent modification of the HP included a check valve added to prevent the spread of microorganisms into the DUWS. The check valve, however, does not sufficiently prevent the contamination of the air supply system. Thus, the development of a new high-speed HP to prevent contamination of the internal water and air lines became necessary. The new Air Flushing Clean System (AFCS) creates a positive pressure inside the HP that is maintained for 10 to 20 sec even after the turbine is stopped.

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Epidemiologic studies in dentistry have focused on infections with hepatitis B virus (HBV) and human immunodeficiency virus (HIV).³⁻⁷ The risk of dentist-to-patient transmission of such blood-borne diseases appears to be small. We evaluated the ability of the AFCS to prevent cross-contamination using *in vitro* methods with two strains of bacteria.

MATERIALS AND METHODS

Bacterial strains

Staphylococcus aureus FDA 209 P was provided by Dr. Osano, Department of Bacteriology, School of Dentistry, Aichi-Gakuin University. *Streptococcus mutans* ATCC 25175 was obtained from our laboratory stock.

Materials

Bacterial strains were grown in brain heart infusion (BHI) broth and Trypticase soy broth (TSB) (BBL Becton Dickinson, Cockeysville, MD). BHI agar was purchased from Eiken Kagaku-Kogyo Co., Tokyo, and defibrinized horse blood was from Nippon Bio-Test Laboratory Inc., Tokyo. The AFCS anti-cross-contamination device, the dental chair unit SMILY Fine GM-RL, and connected HP OT-TDL4H were provided by Osada Electric Co., Ltd., Osaka. The AFCS device was developed in 1992 to prevent contamination by bacteria and viruses. The dental units had not previously been used clinically.

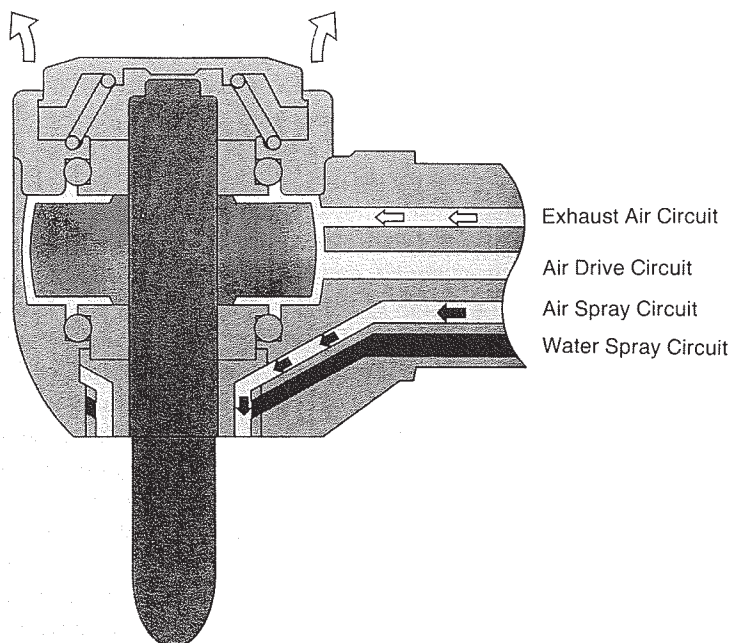


Fig. 1. Cross-section of head of Air Flushing Clean System (AFCS)

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Fig. 1 shows that the AFCS air spray valve opens at the end of the air spray circuit. When the foot switch is on (Fig. 2), the device supplies air drive, which then rotates the rotor and returns through the exhaust circuit, thus cleaning the turbine head area. An air spray will mix with the water spray, while flushing air at low pressure (0.5kg/cm^2) is added to the mixture. The air mixture is then ventilated. When the foot switch is turned off (Fig. 2), the circuit instantly supplies flushing air and chip air to the exhaust circuit and air spray circuit. Air is then blown out of small holes and the head area is cleaned by the positive pressure. The rotor stops more quickly than earlier types because the air jet flows in the opposite direction of the exhaust. The water around the inlet pipe also stops. The contamination area inside the dental unit is thus limited because the rotor and the retraction valve have already stopped.

In the present experiments, both water and air filters (Osada Electric Co., Ltd.) were used to eliminate water hose contamination.

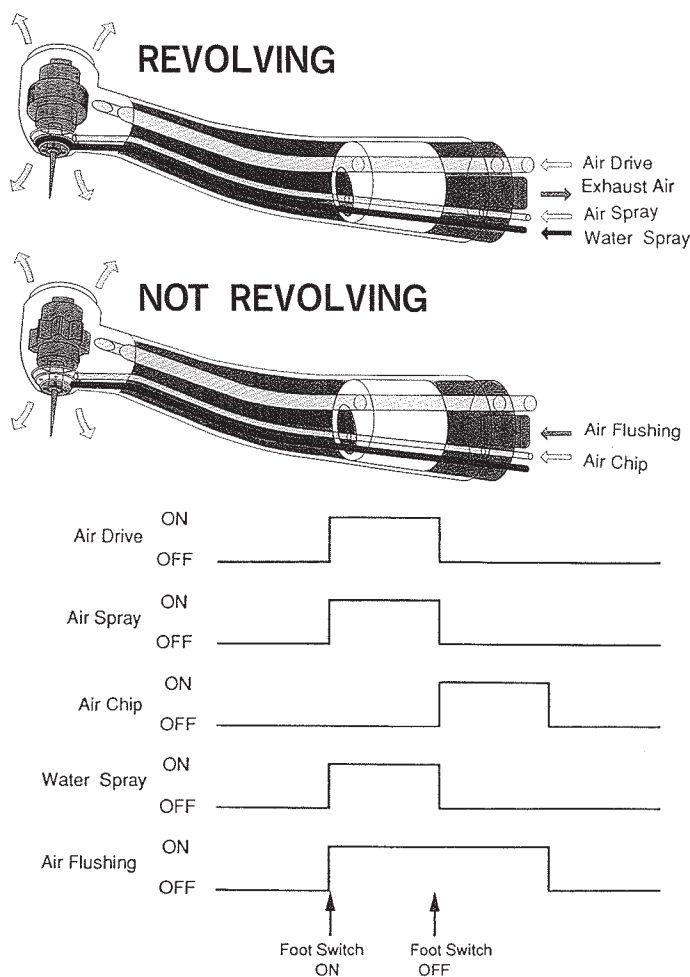


Fig. 2. Illustration showing mechanism of AFCS

Methods

Before performing procedures A, B and C, the absence of contamination in the internal components of the dental unit was demonstrated by the absence of colony formation. Experimental procedures are shown in Fig. 3.

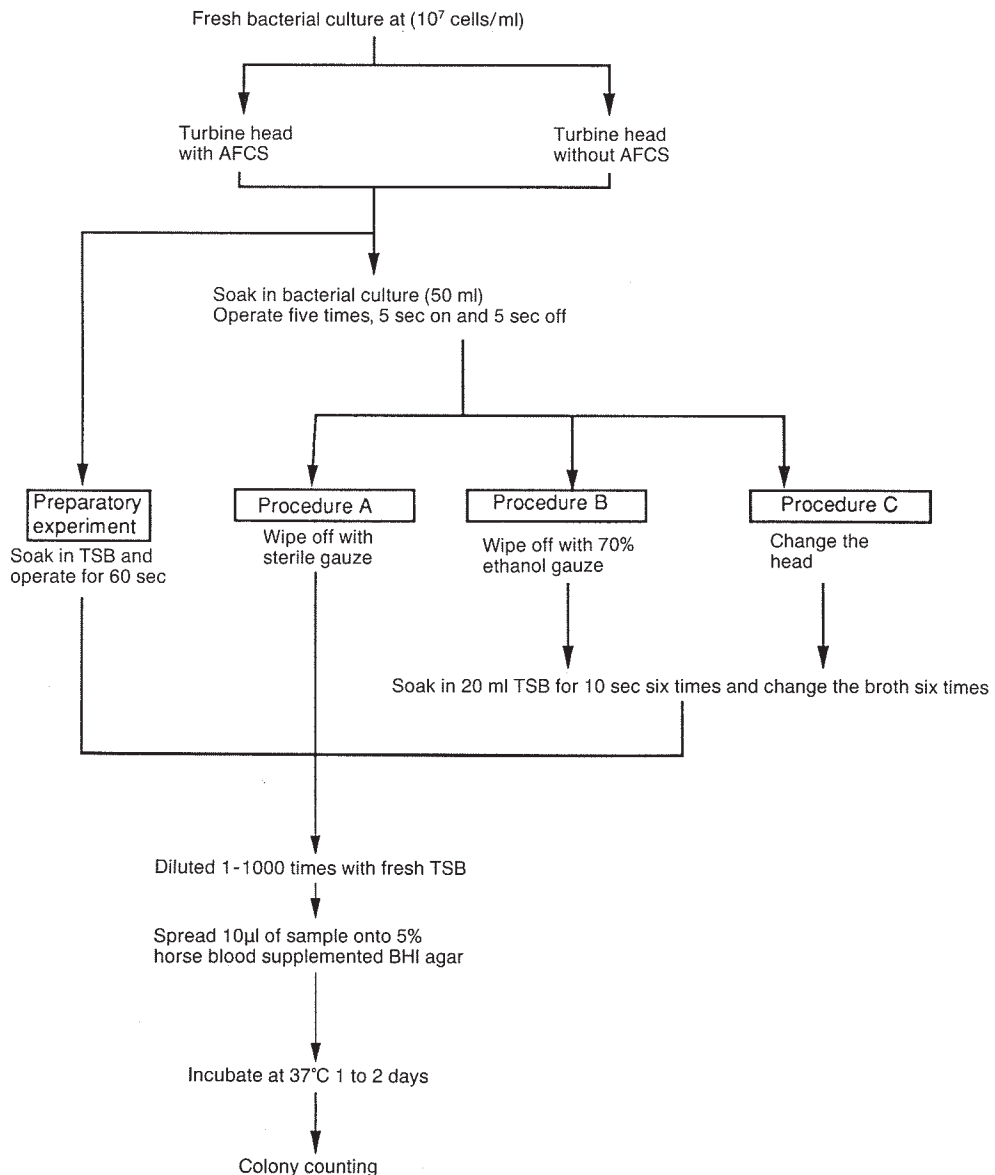


Fig. 3. Experimental protocol

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Preparatory experiment

The heads of the HP with and without the AFCS were soaked in 20ml of TSB and operated for 60 sec. The TSB was then diluted 1–1000 times with fresh TSB, and aliquots (10 μ l/each) were removed and inoculated onto BHI agar plates containing 5% horse blood. These plates were incubated at 37°C for 1 to 2 days under aerobic and anaerobic conditions, and colony forming units (CFUs) were counted.

Procedure A

This procedure consisted of four steps:

1) The two strains of bacteria (*S. aureus* 209 P and *S. mutans* 25175) were grown in 50 ml volumes of BHI broth to approximately 10^7 CFU/ml. 2) The heads of the HP with and without the AFCS were soaked in the bacterial culture, and operated five times at 5-sec pulse flushing (each flushing follows 5-sec intervals). 3) The turbine head was wiped with sterile gauze, soaked, and operated for 60 sec in 20 ml of TSB. 4) TSB was diluted 1–1000 times with fresh TSB; aliquots (10 μ l/each) were removed and inoculated onto BHI agar plate containing 5% defibrinized horse blood. Plates were then incubated at 37°C for 1 to 2 days aerobically for *S. aureus* 209 P and anaerobically for *S. mutans* 25175, and CFUs were counted.

Procedure B

To reduce bacterial contamination, steps 1 and 2 above were repeated. The head of the turbine was wiped off with 70% ethanol gauze as in step 3. 5) Six samples of water, sprayed out for 10 sec each, were collected in bottles containing 20 ml of TSB. Step 4 above was then performed.

Procedure C

After completing steps 1 and 2, the handpiece was replaced by a new autoclaved one, and steps 5 and 4 were again followed.

RESULTS

After confirmation of the absence of sample contamination in the preparatory experiment, the decontamination effects of procedures A, B and C were compared. As shown in Table 1, the decontamination effect of the AFCS was clearly observed.

Table 1. Residual Bacteria Recovered from Contaminated Handpieces in Procedures A, B and C

Sterilization treatment	CFU/ml (%)			
	<i>S. aureus</i> 209 P		<i>S. mutans</i> 25175	
	without AFCS	with AFCS	without AFCS	with AFCS
Procedure A	1.92×10^6 (100)	2.24×10^5 (11.7)	2.07×10^7 (100)	8.00×10^5 (3.86)
Procedure B	1.01×10^6 (52.6)	2.94×10^4 (1.53)	1.59×10^7 (76.8)	2.97×10^5 (1.43)
Procedure C	4.61×10^5 (24.0)	0 (0.0)	5.14×10^6 (24.8)	0 (0.0)

For Procedure A, contamination by *S. aureus* was decreased to 11.7% by using the AFCS. *S. mutans* contamination decreased to 3.86%. For Procedure B, use of the AFCS decreased con-

tamination by *S. aureus* to 1.53%, and that by *S. mutans* to 1.43%. For Procedure C, complete decontamination (to 0.0%) was achieved for both bacterial strains by using the AFCS.

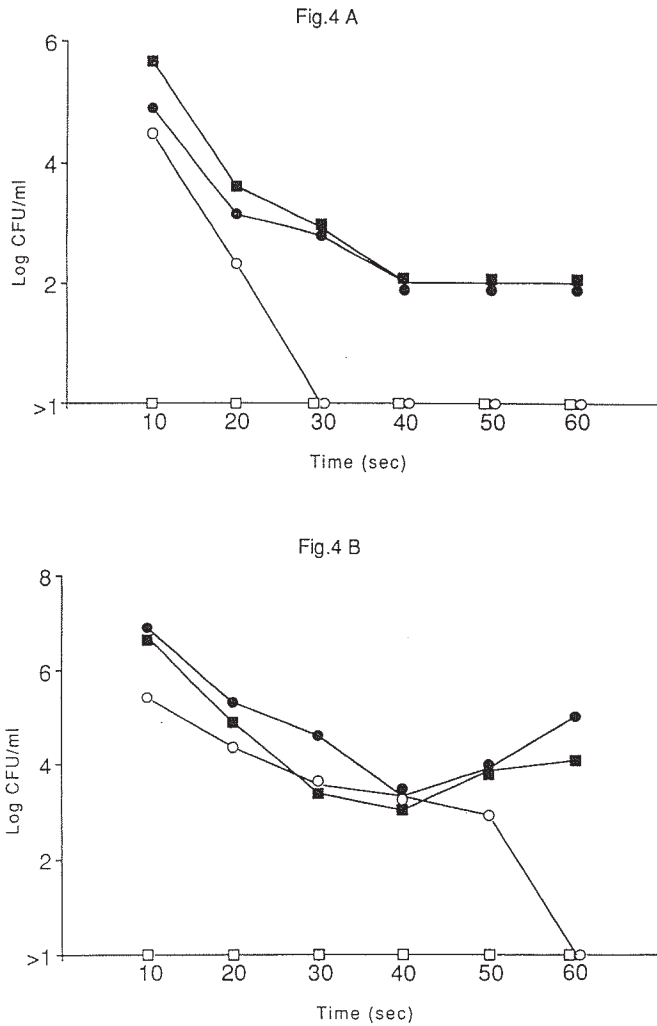


Fig. 4. Decontamination effects of AFCS on sucking back *S. aureus* FDA 209P (A) and *S. mutans* ATCC 25175 (B). CFUs are per ml of dental unit water supply flushed from the turbine heads. Symbols: ■, Procedure B with AFCS; ○, Procedure B without AFCS; □, Procedure C with AFCS; ●, Procedure C without AFCS.

Figs. 4 A and B indicate the change in the number of CFUs flushed from the air and water outlets. Without the AFCS, more than 10^2 CFU/ml of bacteria was flushed out of the outlets, even when the HP was changed. With the AFCS, changing the HP or running the unit for 30 to

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60 sec was extremely effective in reducing the bacterial contamination. Flushing the HP with water by running it for 20 to 30 seconds,¹⁷⁾ the established technique, was ineffective for decontamination without the AFCS.

DISCUSSION

HIV transmission from an American dentist to five of his patients in Florida was reported in June 1991.¹⁹⁾ The dental HP has since been a suspected source of infection. Although the incidence of HIV infection from dental treatment is very low,²⁰⁾ the above report had a strong impact on dentists in the United States. In July 1992, the Bloodborne Pathogens Standard of the Occupational Safety and Health Administration²¹⁾ was instituted, making it mandatory for all dentists and employees to be administered HBV vaccine. In August 1992, the American Dental Association (ADA) revised their "infection control recommendations for the dental office and dental laboratory"²²⁾ just four years after the previous revision.¹⁸⁾ HPs were initially classified as sterilizable or not. In the latest revision,¹⁸⁾ however, description of any HP that is not sterilizable was eliminated. As a result of the Florida incident, the goals are to destroy not only weak viruses like HIV, but all microorganisms, including spores in the dental setting. However, this is technically difficult and presents an economic burden.

The increasing number of patients infected with HBV and HCV as well as those immunologically compromised,⁹⁻¹⁶⁾ has made infection control the first priority. A report of infection by *Pseudomonas aeruginosa* in two compromised patients from the cooling water tube of a HP¹⁷⁾ led to a recommendation for using disposable instruments.⁸⁾ The AFCS was therefore developed to prevent contamination by bacteria and viruses in the dental setting.

Our study demonstrated that $2 \times 10^{6-7}$ CFU/ml of bacteria were present when the conventional dental unit system was used. Wiping the outside of the HP with ethanol gauze was ineffective since 50% to 70% of the bacteria remained. Exchanging the HP with an autoclaved one eliminated only 75% of the bacteria. Thus, patients treated with old equipment are at a greater risk of bacterial and possibly viral cross-contamination. Complete cleaning of HPs by 70% ethanol cannot be achieved because of the uneven surface. Even if the HP is replaced with a new one, contamination of the proximal tubes can not be eliminated. Considerable improvement in decontamination was observed when the AFCS was used, with no bacteria detected following replacement of the HP with an autoclaved HP. With simple cleaning by ethanol gauze alone, no bacteria was detected after a free run of the HP for 40 to 50 sec.

Our results indicate that the AFCS is effective in protecting the inner area of the HP from contamination. The ADA recommends a free run of the HP for 20 to 30 sec to prevent contamination.¹⁸⁾ Our study was performed under more severe conditions than those observed in actual clinical applications.

The ADA recommendations for contamination-free dental treatment are gradually being accepted world-wide. We hope the clinical application of the AFCS will contribute to the safety of both dental patients and dentists.

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