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The in vivo contamination of air-driven low-speed handpieces with prophylaxis angles

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According to the Centers for Disease Control and Prevention, practitioners should “clean and heat-sterilize handpieces and other intraoral instruments that can be removed from the air and waterlines of dental units between patients.”¹ Studies of high-speed handpieces using dye expulsion have confirmed the potential for retraction of oral fluids into internal compartments of the device.^{2,3} Studies using laboratory models also indicate the possibility for retention of viral DNA and viable viruses inside both high-speed handpieces and prophylaxis angles.^{4,5} The potential for contamination of the internal surface of other devices (for example, low-speed handpieces) has not been studied clinically.

The standard of care is to heat-sterilize high-speed dental handpieces after each use, as studies have demonstrated the potential for internal contamination during use that could lead to cross-contamination.²⁻¹³ The justification for heat-sterilizing low-speed handpiece systems is less clear. Compressed air is needed to operate air-driven low-speed handpieces, and it must be reduced or allowed to escape to prevent excessive heat buildup. All disposable and reusable prophylaxis

ABSTRACT

Background. The authors conducted an in vivo study to determine if low-speed handpiece motors can become contaminated with oral flora when used with prophylaxis angles.

Methods. This crossover study involved 20 subjects, two types of handpieces and three prophylaxis angles. The authors used each handpiece/prophylaxis angle system to polish teeth. They then collected samples, spiral-plated the specimens and incubated them at 37°C anaerobically and aerobically (with 5 percent carbon dioxide). After incubation, the authors examined the plates for the presence of bacterial colonies.

Results. At least 75 percent of the handpiece/prophylaxis angle systems used on the 20 subjects had bacterial contamination for at least one cultured area. Of the 420 specimens, 258 (61.4 percent) produced bacterial growth. Contamination varied from zero to 6,300 colony-forming units per milliliter.

Conclusions. These data suggest that the internal surfaces of low-speed handpieces can become microbially contaminated during use with prophylaxis angles.

Clinical Implications. Unless low-speed handpieces are sterilized properly after each use, they pose a risk for crossinfection.

Key Words. Infection control; handpiece; prophylaxis angle; contamination; sterilization.

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laxis angles have a vent that helps reduce or eliminate excessive heat buildup, and it helps prevent the handpiece from being a sealed system, which may contribute to internal contamination of the handpiece. If bacterial contaminants escape through the vent but remain within the handpiece, this could lead to subsequent cross-contamination unless the low-speed handpiece is heat-sterilized between each use. There is, however, only preliminary information concerning the internal contamination of low-speed handpiece systems during use.^{14,15}

A recent *in vitro* study demonstrated microbial movement into and out of two types of low-speed handpieces attached to eight different types of disposable or reusable prophylaxis angles.¹⁵ Angles were operated in solution of *Geobacillus stearothermophilus*, and then inner surfaces were sampled. The authors tested outward movement by inoculating spores onto the gears of sterilized handpiece motors. Then they submerged the prophylaxis angles and handpieces in beakers of sterile phosphate-buffered saline (PBS) and operated them. They then collected specimens of PBS from the beakers, as well as specimens from the inside of the angle and nose cone, the gears of the nose cone and motor, to evaluate contamination. Results indicated that the spores traveled into the motor 20 percent of the time. When the motor gears were contaminated, the test bacterium traveled beyond the prophylaxis cup, out of the prophylaxis angle and into the PBS solution in 75 of 160 cases (47 percent). This study indicates that internal contamination of low-speed handpiece motors can occur when used with prophylaxis angles. Movement of bacteria, both inward and outward, was shown for all 14 combinations tested.

These results suggest a need for an *in vivo* study examining the same hypothesis. We conducted a study to investigate whether low-speed handpieces with prophylaxis angles can become contaminated with oral flora during clinical use. Our hypothesis was that microbes could enter the prophylaxis angle/handpiece system at the prophylaxis angle's tip and travel to the gears of the air-driven handpiece motor.

SUBJECTS, MATERIALS AND METHODS

Subjects. The Indiana University-Purdue University of Indianapolis Institutional Review Board (approval number 0605-74) reviewed and approved our study protocol. We recruited 20 healthy adult subjects (average age 39.8 years;

range, 22-59 years). Our inclusion criteria were that subjects have a minimum of 20 teeth, have good dental health, have a history of a prophylaxis within the last two years and not have a history of untreated periodontal disease. Our exclusion criteria included the subjects' having any significant medical condition or systemic disease requiring them to undergo subacute bacterial endocarditis prophylaxis or being unable to participate in six visits. Subjects provided written informed consent before participation.

Study design. The subjects participated in a randomized, three-by-two crossover study. They underwent a full-mouth tooth polishing performed by a single investigator (S.H.) once a week for six weeks. Each subject received a full-mouth polishing with two test handpieces connected to each of three prophylaxis angles. We randomized polishing time to three-, four- and five-minute intervals. We then aseptically disassembled the handpieces and took specimens for microbial analysis.

Low-speed handpieces. We used two handpieces. One was the Prophy Star (Star Dental, Lancaster, Pa.) single-piece low-speed handpiece. The other was the Titan 3 (Star Dental) two-piece low-speed handpiece. Both handpieces were connected to a dental unit (Excellence series, A-Dec, Newberg, Ore.). We sterilized the handpieces in a steam autoclave for 30 minutes at 121°C before use.

Prophylaxis angles. We tested three prophylaxis angles. Two were disposable, and one was reusable. The disposable angles were Nupro revolv (the firm style) (Dentsply, York, Pa.) and Original Green With Regular White Cup (Denticator, Earth City, Mo.). The reusable metal prophylaxis angle was the TS2 Prophy Angle (metal) with Traditional Web Prophy Cup Screw Type Firm White (Young Dental, Carpentersville, Ill.). We sterilized the reusable prophylaxis angle in the same manner as we sterilized the low-speed handpieces. Each prophylaxis angle and its disposable prophylaxis cup came from the same lot. We selected the best- and worst-performing prophylaxis angles from our previous *in vitro* study for this study.¹⁵

Negative controls. We tested both handpieces with each of the three prophylaxis angles attached

ABBREVIATION KEY. **ETSA:** Enriched trypticase soy agar. **PBS:** Phosphate-buffered saline.

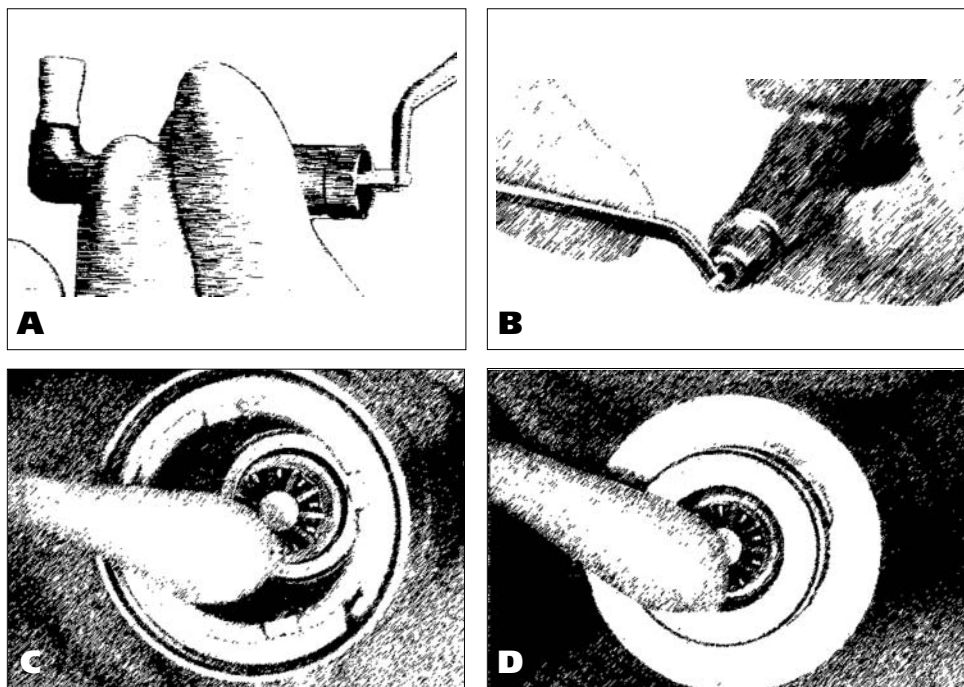


Figure 1. The four areas from which specimens were collected from the low-speed handpiece/prophylaxis angle system. **A.** Example of the inside of the prophylaxis angle. **B.** Example of the inside of the nose cone. **C.** Example of gears of the nose cone. **D.** Example of gears of the motor.

two times for sterility. We assembled the sterilized handpieces and angles as described above, operated them for five minutes using the same dental units as we used with the subjects and then analyzed them for contamination. We did not use these negative control handpiece/prophylaxis angle systems intraorally, but we ran their motors to show that the ambient air driving the handpiece motors did not contain microorganisms and to assess the aseptic nature of the procedure used.

Clinical protocol. We assembled the handpieces and angles in a biological safety cabinet (Class II, Type A/B3, NuAire, Plymouth, Minn.) using aseptic techniques. We removed the sterilized handpieces from their sterilization pouches and covered them with disposable plastic sleeves (Low Speed Handpiece Sleeve, Denticator). We attached one prophylaxis angle with cup to the handpiece and extended the sleeve to cover the angle. We used the handpiece/prophy angle systems to polish subjects' teeth for a randomized length of time (three, four or five minutes), using a fine orange polishing paste that did not contain fluoride. Subjects returned at weekly intervals for polishing with another handpiece/prophylaxis angle system until all six combinations were tested.

Microbial analysis. After we clinically tested

the handpieces, we disassembled the components aseptically. We collected samples from the two-unit handpiece/prophylaxis angle system from four areas: the internal shaft of the prophylaxis angle where the angle attached to the nose cone, the internal shaft on the superior end of the nose cone, the gears on the inferior end of the nose cone and the gears of the motor (Figure 1). We collected samples from the single-piece handpiece/prophylaxis angle system from three areas: the internal shaft of the prophylaxis angle where the angle attached to the nose cone, the internal shaft on the superior end of the nose cone and the gears of the motor. Owing to the design of the single-piece handpiece, which needs to be disassembled completely to access the motor gears, we did not collect samples from the gears on the interior end of the nose cone. We repeated these sampling steps weekly until we tested each type of handpiece/prophylaxis angle system.

We used sterile cotton-tipped applicators and sterile extracoarse paper points to collect samples from the handpiece/prophylaxis angle systems. We swiped the entire area of each site three times for five seconds. We then placed the swabs and paper points individually into 2 milliliters of PBS (0.01 molar, pH 7.2) and mixed them vigorously for 30 seconds, after which we spiral-plated 0.05 mL onto enriched trypticase soy agar (ETSA) plates (BD, Franklin Lakes, N.J.). ETSA is a nonselective medium that supports the growth of many types of microorganisms.

We incubated the ETSA plates anaerobically (GasPak Plus, Disposable Hydrogen + Carbon Dioxide Generator Envelope, BD) at 37°C for seven days and aerobically supplemented them with carbon dioxide (CO₂ Incubator, ESPEC, Osaka, Japan). After incubation, we analyzed the

ETSA plates for the presence of bacterial colonies. Contamination levels were expressed as colony-forming units per milliliter (CFU/mL).

Each subject contributed three specimens a week when we used a single-piece handpiece and four specimens a week when we used a two-piece handpiece. We treated a single subject with three single-piece handpiece/prophylaxis angle systems for a total of nine specimens. We treated a single subject with three two-piece handpiece/prophylaxis angle systems for a total of 12 specimens. Therefore, the total number of specimens taken from a single subject was 21, and the total number of specimens taken from all subjects was 420.

Data analysis. We defined contamination as a bacterial count greater than zero. We calculated the percentage of samples with contamination for each handpiece/prophylaxis angle system, sampling area and culturing method type. We used separate logistic models fit using generalized estimating equation methodology to compare the overall percentage of contamination between two-piece and single-piece handpieces and the overall percentage of contamination between aerobic and anaerobic cultures. We calculated the total bacteria count for each subject by adding counts across areas and bacteria types (anaerobic and aerobic) for each handpiece/prophylaxis angle system. We compared total counts between handpiece/prophylaxis angle systems using a linear model with parameters for handpiece, prophylaxis angle, handpiece-by-prophylaxis angle interaction and random subject effect. We adjusted comparisons of mean counts between the six handpiece/prophylaxis angle systems by using a Tukey-Kramer adjustment. We compared the mean total count between operation times by using an analysis of variance model for each handpiece/prophylaxis angle system. We used a software package (SAS Version 9.1, SAS, Cary, N.C.) for analyses.

TABLE 1

Percentage of bacterial contamination, by handpiece and prophylaxis angle.				
HANDPIECE	PROPHYLAXIS ANGLE*	BACTERIAL CONTAMINATION		
		No. of Subjects (N = 20)	%	95% Confidence Interval
Two-Piece	Original Green With Regular White Cup TS2 Prophy Angle (metal) Nupro revolv (firm)	19	95.0	75.1 to 99.9
		17	85.0	62.1 to 96.8
		20	100.0	83.2 to 100.0
Single-Piece	Original Green With Regular White Cup TS2 Prophy Angle (metal) Nupro revolv (firm)	18	90.0	68.3 to 98.8
		18	90.0	68.3 to 98.8
		15	75.0	50.9 to 91.3

* The prophylaxis angles' manufacturers are as follows: Original Green With Regular White Cup (Denticator, Earth City, Mo.), TS2 Prophy Angle (metal) (Young Dental, Carpentersville, Ill.) and Nupro revolv (firm) (Dentsply, York, Pa.).

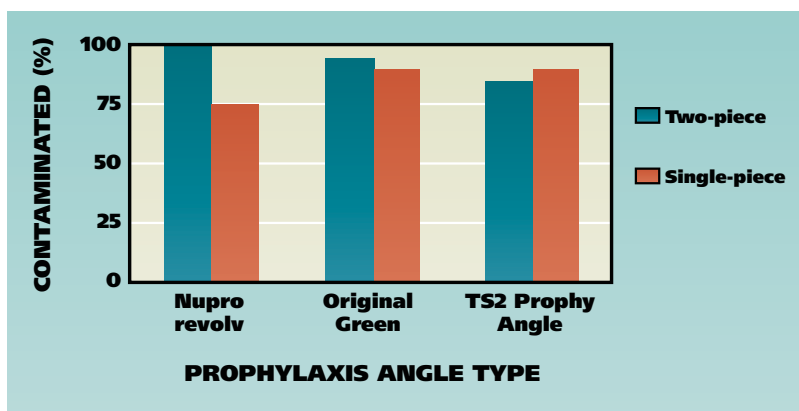


Figure 2. Percentage contamination by either bacteria type by handpiece and prophylaxis angle. The prophylaxis angles' manufacturers are as follows: Original Green With Regular White Cup (Denticator, Earth City, Mo.), TS2 Prophy Angle (metal) (Young Dental, Carpentersville, Ill.) and Nupro revolv (firm) (Dentsply, York, Pa.).

RESULTS

Twenty subjects completed the study, and we collected and cultured 420 specimens. No serious adverse events occurred that were related to the study or otherwise. For each of the six handpieces/prophylaxis angle systems, at least 75 percent of the handpiece/prophylaxis angle systems used on the 20 subjects had bacterial contamination for at least one cultured area (Table 1 and Figure 2). Contamination ranged from 75 to 100 percent; the single-piece handpiece with the Nupro revolv prophylaxis angle had the smallest percentage of contamination (75 percent). Of the 420 sites sampled, 258 (61.4 percent) produced bacterial growth. Contamination varied from zero to 6,300 CFU/mL per specimen (0-4,500 CFU/mL for anaerobic bacteria; 0-5,000 CFU/mL for

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TABLE 2

Comparison of contamination by handpiece and bacteria type.				
COMPARISONS	NO. CONTAMINATED	TOTAL NO.	%	P VALUE*
Handpiece Type				
Two-piece	56	60	93.3	.09
Single-piece	51	60	85.0	
Bacteria Types				
Aerobic	89	120	74.2	.86
Anaerobic	90	120	75.0	
Areas for Each Handpiece				
Two-piece				.12
Angle	45	60	75.0	
Nosecone	37	60	61.7	
Gear	31	60	51.7	
Base	40	60	66.7	
Single-piece				.91
Angle	35	60	58.3	
Nosecone	34	60	56.7	
Base	36	60	60.0	

* Calculated with logistic models fit with generalized estimating equation methodology.

aerobic bacteria).

When we compared the overall contamination of two-piece handpieces with that of single-piece handpieces, we found no significant difference (Table 2). There was no significant difference between the percentage of samples contaminated with aerobic bacteria and the percentage of specimens contaminated with anaerobic bacteria. When we compared the percentage of specimens in each handpiece area contaminated by either anaerobic or aerobic bacteria, we found no significant difference between the areas in two-piece or single-piece handpieces. We found no significant difference in mean total bacteria count (CFU/mL) between any of the handpiece/prophylaxis angle systems (Table 3). We polished each subject's teeth for an average of four minutes, but the polishing times were randomized to three, four or five minutes at each visit. There was no significant difference in the amount of mean bacterial count (CFU/mL) between the randomized operation times (Table 3).

The tests of the negative controls did not result in any bacterial growth on the ETSA plates. We found no bacterial contamination after running the sterile handpieces and prophylaxis angles for five minutes. The lack of bacterial growth confirms that we performed the assembly and disassembly of the handpieces/prophylaxis angle systems and culturing techniques in an aseptic manner.

DISCUSSION

The results of our in vivo study support those of an in vitro study examining the same hypothesis.¹¹ In our study, we modeled the operation of polishing teeth in a healthy patient using a handpiece/prophylaxis angle system in an oral environment. In our study, polishing resulted in the movement of microbes to an internal component of the handpiece 75 to 100 percent of the time.

There are limitations to any clinical trial. In our study, we were looking for the presence or absence of any bacteria to justify sterilization of low-speed handpieces. We used only two kinds of handpieces and three types of prophylaxis angles. We did not determine the microbial species in the specimens nor did we know the pathogenic potential for the kinds of bacterial cultured.

Instead, we were assessing the presence of oral microflora only. Since the control specimens were negative, we know that the bacterial growth resulted from the subjects. We found higher levels of contamination in this in vivo study than we found in our in vitro study.¹⁵ In the in vitro study, we collected specimens of only one type of organism. It is possible the nonselective manner of incubation in this in vivo study resulted in more bacterial growth from the variety of oral microflora that are present at any time. Additionally, the subjects were an inconsistent and uncontrollable source of oral microflora.

These results support our hypothesis that oral bacterial contamination would be found on internal surfaces of handpieces after use. We attempted to simulate typical patient conditions. Low-speed handpieces are used multiple times during a typical day to polish teeth after a dental prophylaxis or after periodontal maintenance treatment. If the internal surfaces of low-speed handpieces become contaminated with oral bacteria, there is a possibility that these organisms can be transmitted to the next patient with whom the handpiece is used. Considering the number of times a handpiece might be used in a day, the potential for cross-contamination is substantial if these devices are not heat-sterilized after each use. In vitro studies have shown that bacterial microbes can be expelled from the low-speed handpiece.^{14,15} In light of a recent report of

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TABLE 3

Mean total bacterial count (CFU/mL*) by operation time, handpiece and prophylaxis angle.

HANDPIECE	PROPHYLAXIS ANGLE†	OPERATION TIME (MINUTES)	NO. OF SUBJECTS	MEAN (CFU/mL)	STANDARD DEVIATION (CFU/mL)	MINIMUM (CFU/mL)	MEDIAN (CFU/mL)	MAXIMUM (CFU/mL)	P VALUE‡
Two-Piece	Original Green With Regular White Cup	3	8	633	775	60	170	2,240	.49
		4	6	297	366	0	140	960	
		5	6	563	289	180	590	880	
	TS2 Prophy Angle (metal)	3	6	327	208	40	410	560	.25
		4	7	106	64	0	100	200	
		5	7	109	89	0	120	240	
	Nupro revolv (firm)	3	6	910	1,509	100	310	3,980	.81
		4	7	437	267	200	300	940	
		5	7	2,906	3,911	20	540	8,680	
Single-Piece	Original Green With Regular White Cup	3	6	147	117	0	160	280	.28
		4	7	377	473	0	160	1,320	
		5	7	157	126	20	100	400	
	TS2 Prophy Angle (metal)	3	7	477	691	140	220	2,040	.09
		4	7	180	179	0	120	520	
		5	6	1,307	2,462	0	380	6,320	
	Nupro revolv (firm)	3	7	111	194	0	20	520	.53
		4	7	331	416	0	260	1,200	
		5	6	467	519	0	350	1,300	

* CFU/mL: Colony-forming units per milliliter.
 † The prophylaxis angles' manufacturers are as follows: Original Green With Regular White Cup (Denticator, Earth City, Mo.), TS2 Prophy Angle (metal) (Young Dental, Carpentersville, Ill.) and Nupro revolv (firm) (Dentsply, York, Pa.).
 ‡ P values were calculated using analysis of variance.

patient-to-patient transmission of hepatitis B in the dental office,¹⁶ it is possible that viral microorganisms also may be transmitted in this manner.

It also is possible that HIV and other blood-borne pathogens might migrate into the handpieces. The procedures we followed in our study did not induce bleeding, but bloodborne pathogens can be present in saliva without blood being visible. We did not test specifically for the presence of bloodborne pathogens in the handpieces.

CONCLUSION

We found that bacterial contamination levels were similar for each of the six handpiece/prophylaxis angle combinations. The results of our in vivo study indicate that the internal surfaces of low-speed handpiece motors can become contaminated with oral bacteria after being used to polish teeth. We recommend that low-speed handpieces be heat-sterilized after each use. ■

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