AIRBORNE ISSUES

Airborne Spread of Disease — The Implications for Dentistry

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ABSTRACT

The potential for the airborne spread of disease has been recognized for many years. Recent studies have shown that this mode for disease transmission is capable of spreading a fatal disease such as Severe Acute Respiratory Syndrome over a wide area. Many dental procedures produce extensive aerosols and splatter that are routinely contaminated with bacteria, viruses, and blood. In the past, the potential for these aerosols and splatter to be a vector for disease spread has not been emphasized in dental infection control. Recently published data shows a need to reassess the potential for dental aerosols and splatter to spread disease and the need for their control. Simple and inexpensive methods for the control of dental aerosols and splatter are given. Dental personnel are urged to make the control of aerosols a standard part of their infection control procedures.

The potential for diseases to be spread via an airborne route has long been recognized. Historically, it was felt that diseases could be spread by noxious vapors in the air. This belief is reflected in the name of the disease malaria. In Latin, the word malaria literally means "bad air." As epidemiology progressed, many of the diseases once thought to be spread by an airborne route were found to have other means of transmission. In the case of malaria, it was discovered that the disease was spread by mosquitoes that flew in the night air rather than the night air itself. Possibly due to the fact that many historical diseases were eventually shown to spread primarily through a non-airborne route, the control of airborne infections has not been stressed in many infection control protocols. Recent studies have forced a reassessment of the airborne route of infection and the infection control protocols necessary when airborne contamination is present.

In the recent past, several examples of the airborne spread of disease have been documented in the scientific literature. These include the spread of tuberculosis through the air recirculation system of a commercial airplane[1] and the spread of measles through the air-conditioning system in a pediatrician's

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office.[2] Despite these well-documented cases, some epidemiologists continued to de-emphasize the airborne spread of disease. The recent Severe Acute Respiratory Syndrome outbreak in Hong Kong has forced a review of the potential dangers represented by the airborne route for the spread of infections.

During the early stages of the SARS outbreak in the Amoy Gardens apartment complex in Hong Kong, the spread of the disease to many of the apartments residents was attributed to multiple possible routes. The theoretical routes varied from personal contacts in the common areas of the apartment complex to disease spread by roof rats, a rodent common in Hong Kong.[3] During the SARS outbreak, the Hong Kong authorities and the American Centers for Disease Control issued several news updates stating there was not evidence for the airborne spread of SARS. However, a recent study evaluating the spread of SARS at the Amoy Gardens has shown conclusive evidence that SARS was not only spread by an airborne route to units within the same building as the original case but also to buildings downwind and as much as 60 meters away.[4] Based on this study, the Harvard School of Public Health issued a press release urging that "…the current thinking on how most communicable respiratory infections are spread … needs to be reconsidered." The press release urged that better measures be taken to control air that "…may at times contain infectious airborne aerosol-acquired diseases and viruses."[5] While the Harvard School of Public Health press release did not specifically discuss dental offices, it did implicate hospitals and patient care facilities.

The production of contaminated aerosols and splatter during dental treatment is well documented.[6-8] Nearly 40 years ago, studies by Micik and others showed conclusive data that many dental procedures produce aerosols highly contaminated with bacteria.[9-12] More recent studies have shown that both live organisms and blood components are routinely present in the aerosols from ultrasonic scalers.[13,14] Despite this large body of data, the control of aerosols during dental procedures has largely been ignored in dental infection control recommendations. The strong data for the airborne spread of SARS and the renewed emphasis on the control of airborne infection by one of the premier schools of public health places pressure on the dental community to control of the ubiquitous contaminated aerosols produced during dental treatment.

Dental Procedures Producing Airborne Contamination

Most dental procedures that use power-driven equipment, water sprays, or compressed air will produce highly contaminated aerosols. The high-speed dental handpiece, air-water syringe, ultrasonic scaler, and air polisher all produce a highly visible cloud made up of aerosols and splatter (**Figure 1**). This visible cloud is composed of droplets from the water spray that is used during the procedure and contaminated material originating in the patient's mouth. While the water droplets are the most visible portion of the aerosol/splatter, if ADA precautions for water quality are followed, this visible spray should not represent a major source of airborne contamination. The greatest risk for the airborne spread of disease comes from the bacteria and viruses originating in the patient's mouth.

The patient's saliva, blood, subgingival fluids, and material from the nasopharynx are the greatest reservoir for potentially pathogenic organisms. Aerosols and splatter from these sources of contamination are virtually invisible but are universally present in the air when dental procedures are performed. The production of this type of aerosol and splatter is clearly demonstrated by a study that evaluated the airborne particles produced by an ultrasonic scaler when no coolant water was used.[15] In this in vitro study, several drops of a fluorescent solution were placed on the anterior teeth of a dental model to represent the patient's saliva and blood. The ultrasonic scaler was used to scale the teeth for three seconds. During the use of the ultrasonic scaler, no coolant water was sprayed on the ultrasonic tip so that all aerosol and splatter that was produced during the ultrasonic scaling came from the fluid around the teeth rather than from the coolant water of the ultrasonic instrument. The extent of the aerosol/splatter was measured by evaluating the amount of fluorescence surrounding the dental model. Despite the total lack of coolant water, there was extensive spray extending up to 18 inches from the site where the ultrasonic had been used. This study demonstrated that any fluid such as saliva or blood present at the area of dental treatment will be aerosolized by the ultrasonic scaler and become airborne in the treatment room. The instruments and procedures that have been shown to cause the most airborne contaminations are shown in **Table 1**.

Figure 1. An ultrasonic scaler using standard 17 ml/minute of coolant water. The ultrasonic scaler has consistently been shown to be the dental device that produces the greatest amount of airborne contamination.

Methods of Reducing or Eliminating Airborne Contamination

To reduce patient source contamination, the CDC recommends the use of a rubber dam, where possible, and the routine use of a High Volume Evacuator (HVE). These are termed "work practices."[16] A work practice is

Table 1

Procedures Shown to Produce Airborne Bacterial Contamination

Ultrasonic and sonic scalers	Shown to be the greatest source of airborne contamination. The use of a high volume evacuator will reduce airborne contamination by greater than 95%.
Air polishing	Bacterial counts show that airborne contamination is nearly equal to ultrasonic scalers. Commercially available suction/ barrier devices will reduce airborne contamination by greater than 95%.
Air-water syringe	Bacterial counts indicate that airborne contamination is slightly less than ultrasonic scalers. High volume evacuator will reduce airborne bacteria by nearly 99%.
Tooth preparation with an air turbine handpiece	Minimal airborne contamination if a rubber dam is used

interpreted to mean practices that should always be performed during any dental treatment producing contaminated aerosols/splatter. Where it is possible to use a rubber dam, the only patient source of contamination will come from material arising directly from the tooth. While undoubtedly there will be some bacteria and other organisms arising from the tooth, it is unlikely that there will be significant amounts of saliva or blood components in the aerosols. The risk of significant airborne contamination is minimized when a rubber dam is used. Unfortunately, there are many dental procedures where a rubber dam can't be utilized. In these situations the only method for minimizing airborne contamination is the HVE.

High Volume Evacuation to Control Airborne Contamination

The use of an HVE during dental procedures has been shown to routinely reduce airborne bacterial contamination by greater than 90 percent (**Figure 2**). The ideal technique for using an HVE is with the help of a dental assistant. A well-trained dental assistant is able to place the HVE close to the source of the aerosol and to closely follow the operator while the procedure progresses. Unfortunately, in many instances an assistant is not always available.

Most procedures performed by a dental hygienist are performed without an assistant. Because of this, dental hygiene procedures potentially carry the greatest risk for the airborne transmission of disease. The ultrasonic scaler is routinely used for dental hygiene procedures and has repeatedly been shown to be the greatest producer of aerosol contamination.[8,13,17,18] The operator using an ultrasonic scaler is at greatest risk for airborne disease transmission due to their close proximity to the patient. However, other members of the dental team and other patients may also be at risk. Because a rubber dam cannot be used for dental hygiene procedures, an HVE must always be utilized with an ultrasonic scaler.

The HVE is a routine piece of equipment in dental operatories. In order for a suction device to be classified as a high volume evacuator, the suction equipment must be capable of removing a large volume of air in a short period of time. Most HVE units will remove 80 cubic feet to 100 cubic feet of air per minute. In order to remove this amount of air in a short period of time, the evacuator tip must have a relatively large inside diameter. HVE tips must have an inside diameter of at least 6 mm to 8 mm. A suction system that is not capable of removing a large volume of air in a short period of time, such as a high vacuum/low volume suction system typically used in a hospital, is not an HVE and is not suitable for reducing dental aerosols. A common mistake is to use a small diameter suction tip, such as a saliva ejector, with a system that is capable of removing a large volume of air (i.e., an HVE suction source). While effective for removing fluid build up in the floor of the mouth, the small diameter of a saliva ejector makes it ineffective for removing aerosols (**Figure 3**).

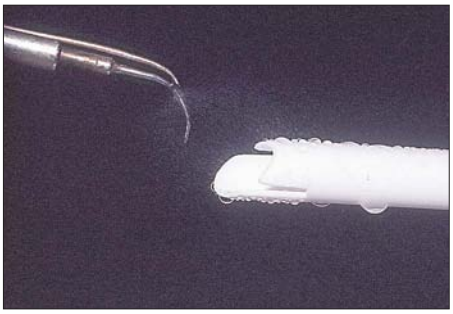

Figure 2. The use of a 6 mm to 8 mm diameter high volume evacuator with an ultrasonic scaler will eliminate almost the entire aerosol. The use of an HVE by an assistant has been shown to reduce airborne contamination by more than 90 percent.

Controlling Aerosols During Dental Procedures

There are three simple and inexpensive procedures that should routinely be utilized to minimize airborne dental contamination during dental procedures. These recommendations are outlined in detail in a recent article in the *Journal of the American Dental Association*.[19] They

Figure 3. The use of a standard small bore saliva ejector is completely ineffective for the removal of the aerosol from an ultrasonic scaler. When placed in its usual position in the floor of the mouth it will be even less effective than shown in the photograph.

are: (1) the routine use of a preprocedural antiseptic rinse, (2) the routine use of standard barrier protection, and (3) the routine use of a large diameter HVE suction. It should be stressed that in order to adequately control aerosol contamination, all three of these procedures must be followed. Using only one or two of these procedures is inadequate. Each of these recommendations is discussed below (**Table 2**).

Step One: Preprocedural Rinses

The use of a preprocedural antiseptic rinse such as chlorhexidine or an essential oil mouthwash have been shown to reduce the number of bacteria that can be cultured from the air during a dental procedure.[20,21] It is unknown to what extent these rinses may affect only the relatively benign free floating bacteria adhering to the mucosa of the mouth and to what extent they will also affect potentially pathogenic bacteria found in the nasopharynx or the periodontal pocket. Due to the fact the mode of action of these rinses is to kill bacteria by direct contact, it is probable that only the superficial bacteria will be affected. It is also likely that the pathogenic bacteria and viruses most likely to spread a serious infection will only be marginally affected by a preprocedural rinse. However, the preprocedural rinse will reduce the number of bacteria, is inexpensive, and easy to use. Rinses are recommended as a part of aerosol contamination control but they should not be relied upon as the only aerosol control.

Step Two: Barriers

The use of basic barrier protection is the standard for all dental procedures. The use of gloves, a well-fitting mask,

Table 2

Methods of Reducing Airborne Contamination

Device	Advantages	Disadvantages
Barrier protection – mask, gloves and eye protection	Routine part of "standard precautions," inexpensive	Masks will only filter out 60% to 95% of airborne contamination, subject to leakage if not well fitted, does not protect when mask is removed after the procedure
Preprocedural rinse with antiseptic mouthwash such as chlorhexidine	Reduces the bacterial count in the mouth, saliva, and air. Inexpensive on a per patient basis.	Tends to be most effective on free-floating organisms. It will not affect (1) biofilm organisms such as plaque (2) subgingival organisms (3) blood from the operative site or (4) organisms from the nasopharynx
High volume evacuator	Will reduce the number of bacteria in the air and remove most of the material generated at the operative site such as bacteria, blood, and viruses. Inexpensive on a per patient basis	When an assistant is not available, it is necessary to use an HVE attached to the instrument or a "dry field" device. A saliva ejector is not an HVE and does not control aerosols.
HEPA room filters and UV treatment of ventilation system	Effective in reducing numbers of airborne organisms	Only effective once the organisms are already in the room air, moderate to extremely expensive, may require engineering changes to the ventilation system

long-sleeve gowns, etc. is a well-established necessity. However, many dental personnel tend to place too great a reliance on the efficacy of barriers. Surgical masks tend to leak around the edges and will only filter out about 60 percent of airborne contamination.[22] An N-95 mask will filter out 95 percent of airborne contamination but is rarely used during dental treatment. Also, dental personnel will frequently remove their mask immediately after treatment has been completed. This exposes them to the smaller particles of contaminated aerosols which have been shown to remain airborne for greater than 30 minutes after the procedure has been completed. These smaller particles are felt to represent the greatest danger for the transmission of disease.[23] Well-fitted masks, gloves, and other barriers, when used with the other recommended measures, are an essential part of protection from droplets and aerosols.

Step Three: High Volume Evacuation

The use of a large bore HVE is the cheapest and most effective method for the removal of airborne contamination but is probably the safeguard that is used least often. This is most often due to the lack of availability of a dental assistant. This is most frequent during dental hygiene procedures where an ultrasonic scaler or an air polisher is used. Several alternatives to the use of an assistant during dental hygiene procedures are readily available. Commercially available are HVE devices that attach to the handpiece of an ultrasonic scaler (**Figure 4**), so-called "dry field" devices that place an HVE in the patient's mouth, and combination barrier and suction devices that attach to air polishers. Other devices have been reported in the literature that consist of an arm that holds a standard disposable HVE suction tip in place during patient treatment.[24] These devices may also be a viable option for aerosol infection control. The use of an HVE is mandatory to the control of aerosol contamination.

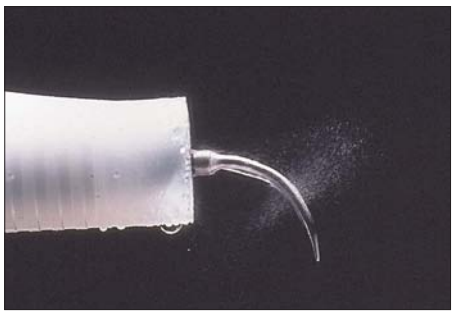

Figure 4. A large-bore high volume evacuator that attaches to the handle of an ultrasonic scaler. This device has been shown to reduce airborne contamination by more than 95 percent.

Air Filters and Air Sanitizers

An additional device to reduce airborne contamination is the use of a high efficiency air filter or a UV "upper room" air sanitizer. The high efficiency particulate air or HEPA filter pulls the air in the room through a filter that is capable of removing most contamination. These are extremely effective in filtering particles from the air of the operatory, but have the disadvantage of requiring a considerable amount of time to circulate the air through the filter and will only remove the contamination that has already entered the air. A UV "upper room" air sanitizer is a unit that is placed in the air-conditioning system. This sanitizer exposes the circulated air to a germicidal ultraviolet light. The installation of this unit usually requires major engineering changes to the air-conditioning system and can be quite expensive.

Filters and sanitizers can both be effective in removing bacteria from the air. The HEPA filter can be placed in an existing operatory with only the expense of the equipment. The UV sanitizer can be considered for new construction or during major remodeling but may be cost prohibitive to retrofit into most existing dental facilities. Both of these devices suffer from the fact that they only remove contamination that has already escaped into the air and are already a risk for dental personnel. The control of airborne contamination at it source, i.e., the patient's mouth, should be the goal of dental infection control. The use of devices that remove existing contamination from the air should not be relied upon as the first line of protection for dental personnel.

Conclusion

The production of contaminated aerosols and splatter during dental procedures is a well-established fact. The control of these contaminated aerosols has not been emphasized in dental infection control. The advent of SARS and the publication of well-designed studies clearly demonstrating the airborne spread of this respiratory disease shows a need for the reassessment of dental infection control procedures for airborne contamination. The use of preprocedural rinses, barriers, and an HVE are three infection control steps that should be standard for all dental procedures that produce aerosols. Routinely following these three steps should reduce or eliminate the possibility for the airborne spread of disease during dental procedures and limit the legal liability of dental clinics. CDA

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