Infection Control

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Exposure Risks and Effect of Infections on Dentistry

Pervasive increases in serious transmissible diseases over the last few decades have created global concern and have affected the treatment approach of all American health care practitioners. Every health care specialty that involves contact with mucosa, blood, or blood-contaminated body fluids is now regulated. The goal is to ensure compliance with standard precautions and other methods to minimize infection risks.7

Although the objective of operative dentistry has been to provide the highest standard of care, a prevailing concern has been to minimize the patient’s anxiety with regard to treatment. Providing a supportive, informal, relaxed, and non-threatening operatory environment has been one emphasis. Although that concern has not waned, emphasis now has expanded to ensuring and showing to patients that they are well protected from risks of infectious disease. Universal use of treatment gloves, masks, protective eyewear, overgarments, plastic barriers to protect equipment, proper disinfectants, and instrument sterilization provides a professional health care atmosphere that conveys conscientious protection and treatment according to sound principles of infection control in keeping with current regulations (Online Fig. 19-1).

Environment of the Dental Operatory

To comprehend the problem of microbial contamination that confronts dentistry, it is necessary to examine the dental treatment environment. Because it was poorly understood in the past, personnel went unprotected from unseen exposures. For most of the twentieth century, general dentistry was routinely practiced without barriers to protect eyes, nose, mouth, and hands as shown in Online Figure 19-2. Not until 1991 were dental personnel required to wear gloves, masks, gowns, and protective eyewear while treating patients. Microbial exposures in the dental operatory include air-borne contamination (see Online Fig. 19-2) and direct and indirect contamination of surfaces.

Air-Borne Contamination

A high-speed handpiece is capable of creating air-borne contaminants from bacterial residents in the dental unit water spray system and from microbial contaminants from saliva, tissues, blood, plaque, and fine debris cut from carious teeth (see Online Fig. 19-2). With respect to size, these air-borne contaminants exist in the form of spatter, mists, and aerosols. Aerosols consist of invisible particles ranging from 5 mm to approximately 50 mm that can remain suspended in the air and breathed for hours.2 Aerosols and larger particles may carry agents of any respiratory infection carried by the patient. No scientific evidence indicates, however, that fine aerosols have transmitted the blood-borne infection caused by hepatitis B virus (HBV).3,4 Transmission of human immunodeficiency virus (HIV) by aerosols is even less likely, as evidenced by the extremely low transmissibility of HIV in dental procedures and in the homes of infected persons.5-8 Mists that become visible in a beam of light consist of droplets estimated to approach or exceed 50 mm.9 Heavy mists tend to settle gradually from the air after 5 to 15 minutes.9 Aerosols and mists produced by the cough of a patient with unrecognized active pulmonary or pharyngeal tuberculosis are likely to transmit the infection.10 Spatter consists of particles generally larger than 50 mm and even visible splashes. Spatter has a distinct trajectory, usually falling within 3 feet (R) of the patient’s mouth, having the potential for coating the face and outer garments of the attending personnel.9 Spatter or splashing of mucosa is considered a potential route of infection for dental personnel by blood-borne pathogens.7,11

Barrier protection of personnel using masks, protective eyewear, gloves, and gowns is now a standard requirement for dental procedures. A pretreatment mouthrinse, rubber dam, and high-speed air evacuation also can reduce microbial exposure.9 To help reduce exposure to air-borne particles capable of transmitting respiratory infections, adequate air circulation should be maintained, and masks should be kept in place until air exchange in the room has occurred or until personnel leave the operatory.10

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Direct Contamination

Direct contamination occurs during direct contact with bodily fluids, and this is a major exposure concern for dental personnel.

Indirect Contamination

With saliva-contaminated hands, the hygienist, the dentist, and the assistant could repeatedly contact or handle unprotected operatory surfaces during treatments. The invisible trail of saliva left on such contaminated surfaces often defies either awareness or effective cleanup. Soiled surfaces that are poorly cleaned provide another source of gross environmental contamination and thus potential contamination of personnel and patients. Cross-contamination of patients by such contaminated surfaces was documented in a clinical office radiology setting.12,13

Another study used water-soluble red-fluorescent poster paint (plain water-soluble fluorescent-red tempera in water) as a visible substitute for saliva to elevate awareness and facilitate problem solving in infection control. In this study, a hygienist was photographed treating a manikin fitted with dentures coated with red paint (Online Fig. 19-3).14,15 The results showed how extensively the dental operatory surfaces were smeared; how time consuming, expensive, and difficult it was to clean the contaminated surfaces; and how difficult it was to identify, clean, and disinfect objects covered with actual films of invisible saliva. Red poster paint is still used in dramatic training exercises, workshops, and poster displays to show or evaluate contamination control in dental operatories.

Bacterial contamination of dental operatory surfaces was investigated in 10 private dental offices after the surfaces were cleaned and disinfected.14 Sampling confirmed widespread residual contamination with oral bacteria. Contamination was not controlled by conscientious following of cleaning and disinfecting procedures. Items or areas still contaminated after cleaning included handpieces; unprotected lamp handles; air-water syringe handles; control switches on the patient’s chair; tubes, jars, and canisters of treatment materials; seat edges and rests of the dentist’s and assistant’s chairs; faucet knobs;
cabinet, drawer, and operatory tray handles; room light switches; and operatory telephones. Telephone handles at the receptionists’ desks also became heavily contaminated with bacteria from saliva. Before handpiece sterilization requirements, contaminated handpieces and other equipment were cleaned only by wiping with disinfectant before reuse. (When nondental offices that were never disinfected were sampled as controls, phone handles and other similar surfaces were devoid of bacteria from saliva.) Amalgam mixing equipment, light-curing units, and camera equipment also are subject to heavy contamination by soiled hands. Maintaining no contamination of these items and areas is a priority objective today. Controlling contamination of equipment and personnel is essential to protecting patients and personnel in this operatory zone of potential heavy contamination. Barrier protection of personnel and equipment, instrument sterilization, and methods of avoiding direct contact with various surfaces are necessary.9,11,14

Cross-Infections

Most information on cross-infection and infection control concepts has been derived from data collected in hospitals. Evidence of oral or systemic cross-infections in dentistry is more difficult to obtain because patients may have contracted infections elsewhere, before or after having a dental treatment. Infected patients usually are unaware of the source of their infection and go elsewhere for diagnosis and treatment of nonoral infections. Infection outbreaks usually are detected in patients or personnel only when they occur in clusters recognized by other health care providers or are detected by epidemiologic studies and investigative surveys of personnel.8,16-18

Patient Vulnerability

Although infection risks for dental patients have not been as well investigated as risks of hospital patients, they seem to be low. Nine cluster cases of dentist-to-patient transmission of hepatitis B virus (HBV) and one cluster case of HIV have been documented since 1971. Since 1986, when infection control practices became widespread, no cluster cases of HBV transmission related to dentistry have been reported.8,16-18

Personnel Vulnerability

When dental personnel experience exposure to saliva, blood, and possible injury from sharp instrumentation while treating patients, they are more vulnerable to infections if they have not had the proper immunizations or used the proper protective barriers. It is unfortunate that the need for proper control of exposures and infections was not realized before the occurrence of the blood-borne HBV infection, which poses a serious threat to all dental personnel (see the section on the impact of HBV).19 HIV has not taken a similar or worse toll, primarily because of the implementation of adequate infection control principles and surveillance. Transmission of occupational disease from the patient to the dental health care worker is low.17 Dental personnel who have treated infectious patients on a daily basis for years in hospital dental services have found infection control methods to be highly effective.20 Infection control has helped dramatically reduce the risks and concerns of personnel in private dental offices and has instilled confidence in a safe environment for patients as well as personnel.

Epidemiologic information about HBV, hepatitis C virus (HCV), HIV, and other relevant infections is important. Examining the impact of these serious diseases provides the impetus to use and improve effective methods of infection control. It also may prevent complacency about the risks from current and emerging diseases. The vulnerability of dental personnel that exists before the institution of infection control standards is the best indicator of the potential for infection transmission in dentistry. Findings related to HBV and HIV illustrate this point.

Impact of Hepatitis B Virus

HBV was the first infectious disease to gain attention as a risk for health care personnel who come in contact with blood and other bodily fluids. From 1982 to 1986, various blood sample studies in the United States showed that 14% to 28% of general dentists, 15% of dental assistants, and 17% of dental hygienists had evidence of past infection with HBV.19-22 If only 20% of the approximately 120,000 dentists in the United States had been infected by 1982, 24,000 dentists would have been infected with HBV. With the 2% mortality rate that characterizes HBV, 480 of these infected would have died within 20 to 30 years after initial infection. A vaccine has dramatically curtailed HBV infection among dental personnel who have been effectively immunized. Infection control procedures remain a major concern, however, to prevent cross-infection among patients.11

Impact of Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome

In view of the high HBV infection rate among dental personnel, epidemiologists anticipated that acquired immune deficiency syndrome (AIDS) would decimate the workforce population in dentistry. By the mid-1980s, HIV had infected approximately one million persons in the United States, most of whom were high-risk persons in metropolitan areas. By 1988, of more than 1000 dentists surveyed in high-risk areas who practiced with unprotected hands, only one was found to be infected, and this person claimed no other exposure risks. As of December 2006, no dentists for whom negative HIV blood tests were established at the time of job-related exposure have acquired job-related HIV infection.1,24-26

Public alarm was intense when a Florida dentist with clinical AIDS transmitted his unique strain of HIV to six patients in his large dental practice.27-29 No other instance of clinician-to-patient transmission of HIV has been documented in dentistry. That isolated instance of HIV transmission contrasts dramatically with the transmissibility of HBV. Twenty reports have documented that more than 300 patients treated by HBV-infected health care workers acquired the virus. Nine of the reports in the United States listed more than 140 patients infected with HBV by dental practitioners that caused several deaths.10,29 Evidence indicates that the Florida cluster of HIV infections and most treatment-related HBV infections from infected clinicians to patients could have been prevented by conscientious use of infection control procedures.17,24
Florida outbreak was nonetheless tragic for the individuals and families involved. The ensuing public demand for mandatory testing of all health care personnel was reduced to voluntary testing, and states were required to enforce U.S. Public Health Service guidelines for infection control in all health care facilities. Public concern continues to focus unprecedented attention on the standards of infection control used in all health care professions, particularly in dentistry.

Despite the deficit in patient infection data and the misplaced concern regarding the transmissibility of HIV infection in dentistry, the Florida cluster of HIV infections and Occupational Safety and Health Administration (OSHA) regulations have provided, within a brief time span, a strong impetus to strengthen and control aseptic standards in all health care disciplines. Dental students, auxiliary personnel, and patients all are the final beneficiaries of the dramatic changes that have occurred. Infection control is now accepted as a standard of care by dentists.

Federal and State Regulations to Reduce Exposure Risks from Pathogens in Blood and Other Sources of Infection

The term infection control program has a long tradition in hospital usage. Infection control programs such as those recommended by the Centers for Disease Control and Prevention (CDC) and the American Dental Association (ADA) are designed to protect both patients and personnel.

The federal Occupational Safety and Health Administration (OSHA) uses a different term, exposure control plan, for the required office programs designed to protect workers against risks of exposure to infection. Other agencies’ guidelines and requirements that pertain to areas of infection control not covered by the OSHA are discussed in the next section. State occupational safety and health agencies are now enforcing regulations finalized by the federal OSHA, whose Final Rule (or The Standard) on occupational exposure to blood-borne pathogens was published in December 1991.

The OSHA rule derives from the original Occupational Safety and Health Act passed by the U.S. Congress in 1970. This Act identified employers’ obligations to protect employees from occupational risks. The Act has been the basis for all subsequent federal safety and health regulations. According to the Act, each employer must furnish employees with a place and conditions of employment free from recognized hazards that presently cause, or are likely to cause, death or serious harm to employees as specified in the “General Duty Clause” of the OSHA regulations. The Act created the OSHA in the U.S. Department of Labor. In the late 1980s, labor unions petitioned the OSHA in federal courts to extend chemical hazards protection standards to employees in the health care professions. Shortly thereafter, concerns about the transmission of HIV to health care workers stimulated the unions to take similar action to obtain the OSHA regulation with regard to exposure to blood and bodily fluids among health care personnel.

The Act covers two regulated programs of compliance: (1) the OSHA Hazard Communications Program, which deals with risks from environmental and chemical hazards in the workplace, and (2) the OSHA Bloodborne Pathogens Program, which addresses control of “occupational exposure to blood and other potentially infectious materials.” The OSHA Hazard Communications Program, which also must be implemented in every dental office, applies mainly to chemicals.

All aspects of the OSHA Bloodborne Pathogens program, which aims to protect employees, were required in every dental office by July 6, 1992. Federal Law 42, passed by Congress in 1991, required state public health departments to apply similar standards or follow the CDC guidelines of infection control among all dental care personnel to ensure the protection of patients. Under federal and state laws, “employers (including dentists operating nonincorporated offices) must comply with infection control regulations.”

Preparing a Written Occupational Safety and Health Administration Office Exposure Control Plan: Summary

Exposure Control Plan

A written exposure control plan must be accessible to all the employees who face exposure risks. The plan must be reviewed and updated at least annually and whenever alterations in procedures create new occupational exposures. Dental students do not come directly under OSHA regulations unless they are employees of the school with duties that involve exposure to blood-borne pathogens. In compliance with federal and state policies, school accreditation requirements, and university policies, however, all dental schools have an infection control manual of standard operating procedures that applies to students. These policies usually are based on the school’s OSHA exposure control plan for faculty and staff. As future employers or employees, dental students will have to become acquainted with OSHA’s exposure control plan.

The OSHA exposure control plan uses terms that require definition. Exposure is defined in the OSHA regulation as “specific eye, mouth, other mucous membrane, nonintact skin, or parenteral contact with blood or other potentially infectious materials (OPIM) that results from performance of an employee’s duties.” Only in dentistry is saliva considered a potentially infectious material because oral manipulations and dental treatments routinely cause saliva to become contaminated with the patient’s blood. In dental practice, all patients must be treated with standard precautions to reduce the risk of disease transmission.

Means of compliance are expressed in the OSHA terminology for environmental safety engineers. Work practice controls and engineering controls are terms that describe precautions (e.g., careful handling of sharp instruments and not putting hands into sharps containers) and use of devices to reduce contamination risks (e.g., using high-volume suction, rubber dam, and protective sharps containers). Personal protective equipment (PPE) is the term used for barriers such as gloves, gowns, or masks. Housekeeping is a term that relates to the cleanup of treatment-soiled operatory equipment, instruments, counters, and floors and to the management of used gowns and waste. Housekeeping also relates to cautions for servicing contaminated equipment and using only mechanical means to clean contaminated broken glass.

Dentists should obtain and read a copy of the Final OSHA Rule on Bloodborne Pathogens to be apprised of complete and
Employers must prescribe safe handling of needles and other sharp items. Needles must not be bent or cut. When necessary, needles may be resheathed with mechanical aids or other one-handed techniques.

7. Employers must prescribe disposal of single-use needles, wires, carpules, and sharps as close to the place of use as possible, as soon as feasible, in hard-walled, leak-proof containers that are closable, from which needles cannot be easily spilled. Containers must be red in color or bear a biohazard label and must be kept upright and closed when moved. Teeth must not be discarded into trash but can be given to the patient or discarded in sharps containers.

8. Contaminated reusable sharp instruments must not be stored or processed in a manner that requires exact regulatory details. A summary of the current OSHA regulations specifying what employers must furnish, directions employers must provide, and compliance required of employees is as follows:

1. Employers must provide HBV immunization to employees, without charge, within 10 days of employment. The employer also must provide a copy of the OSHA regulations on blood-borne pathogens (from which this information is taken) to the health care professional responsible for providing HBV vaccination.

2. Employers must mandate that standard precautions be observed to prevent contact with blood and other potentially infectious materials. Saliva is considered a blood-contaminated bodily fluid in relation to dental treatments.

3. Employers must implement engineering controls to reduce the production of contaminated spatter, mists, and aerosols. Examples are use of a rubber dam, high-volume suction, rubber prophy cup instead of brushes, scaling instruments for patients with respiratory infections instead of cavitron, and hard-wall containers to avoid contact with disposable and reusable sharps.

4. Employers must implement work practice control precautions to minimize splashing, spatter, or contact of bare hands with contaminated surfaces. Telephones, switches, door handles, or faucet handles should never come in contact with soiled gloves. The subsequent items below (#5–#18) also are work practice control regulations.

5. Employers must provide facilities and instruction for washing hands after removing gloves and for washing other skin immediately or as soon as feasible after contact with blood or potentially infectious materials.

Online Fig. 19-4 In current dental practice, personal protective equipment (PPE) provides barriers against spatter and aerosols during patient treatments. (From Bird DL, Robinson DS: Modern dental assisting, ed 10, St. Louis, Saunders, 2012.)

Online Fig. 19-5 To remove a contaminated glove, pinch the palm side of the outer cuff surface with the gloved fingers of the other hand. Pull off the glove, inverting it. Both gloves can be removed simultaneously in this manner. Alternatively, after removing one, insert bare fingers under the cuff to grasp and pull off the remaining glove. Discard gloves safely.

Online Fig. 19-6 To wash hands after removing treatment gloves, operate the pump as shown with the clean underside of a wrist. Also, operate faucet handles the same way to avoid contamination or use foot controls. Never touch the handles with contaminated gloves.
employees to reach into containers to retrieve them. A basket or cassette should be used to place instruments into, and retrieve them from, soaking pans and ultrasonic cleaners. Biohazard-labeled or red-colored pans that are leak-proof and puncture-resistant should be used.

9. Employers must prohibit staff from eating, drinking, handling contact lenses, and application (but not wearing) of facial cosmetics in contaminated environments such as operatories and cleanup areas. Storage of food and drinks in refrigerators or other spaces where blood or infectious materials are stored should be banned.

10. Blood and contaminated specimens (e.g., impressions that have not been well cleaned and well disinfected, teeth, biopsy specimens, blood specimens, and culture specimens) to be shipped, transported, or stored should be placed in suitable closed containers that prevent leakage. An adequately strong plastic bag can be used for impressions. The surface of all containers must be clean or enclosed in another clean, red, or biohazard-labeled container.

11. At no cost to employees, employers must provide them with necessary PPE and clear directions for use of appropriate universal barrier protection in treating all patients and for all other contact with blood or other infectious materials (see Online Figs. 19-1 and 2-4). PPE must not allow blood or other potentially infectious material to pass through to contaminate personal clothing, skin, or mucous membranes. Employers must provide protective gloves, or hypoallergenic gloves, as needed; appropriate protective body clothing such as gowns, the type and characteristics of which “depend upon the task and degree of exposure anticipated”; protective eyewear, chin-length face shields, goggles, or glasses with solid protective side shields; masks; pocket resuscitation masks for cardiopulmonary resuscitation; and surgical caps or shoe covers to be worn when required for surgery or whenever heavy contamination can be reasonably anticipated.

12. Employers should ensure that employees correctly use and discard PPE or prepare it properly for reuse. Adequate facilities should be provided to discard gowns or laundry in the location where they are used. A face shield is not a substitute for a mask.

13. As soon as feasible after treatments, staff should attend to housekeeping requirements, including cleanup of floors, countertops, sinks, and other environmental equipment that are subject to contamination. Housekeeping requirements include the changing of protective covers after each appointment; alternatively, contaminated surfaces and operatory equipment items that cannot be covered should be thoroughly cleaned and disinfected; discarded; or removed and sterilized. (See the sections on operatory asepsis, and procedures, materials, and devices for cleaning instruments before sterilization for details.)

14. Employers must provide a written schedule for cleaning and decontaminating equipment, work surfaces, and contaminated floors. For contaminated spills, an appropriate method of cleaning and the application of disinfecting methods should be prescribed. Broken glassware that may be contaminated must be cleaned with mechanical means and never with gloved hands.

15. Contaminated equipment that requires service first must be decontaminated, or a biohazard label must be used to indicate contaminated parts.

16. Contaminated sharps are regulated waste and should be discarded in hard-walled containers. With regard to OSHA requirements in dentistry, regulated waste also means (1) liquid or semi-liquid blood or other potentially infectious materials, (2) contaminated items that would release blood or other potentially infectious materials in a liquid or semi-liquid state if compressed, and (3) items that are caked with blood or other potentially infectious materials and are capable of releasing these materials during handling. Such regulated waste should be disposed of properly in biohazard-labeled or red-colored closable bags or other labeled containers that prevent leakage. Containers contaminated on the outside must be placed in a secondary container. The secondary container also must be closable, prevent leakage, and be red-colored or biohazard-labeled. Containers or bags must be closed when moved. If outsides of reusable containers are likely to become contaminated, they must be inspected, decontaminated, and cleaned on a regularly scheduled basis and as soon as feasible if they become visibly contaminated. Cabinets or other storage areas on the premises in which blood-contaminated waste is stored must be identified by a biohazard label.

17. Reusable contaminated sharp instruments should be placed in a basket in a hard-walled container for transportation to the cleanup area. Personnel must not reach into containers of contaminated sharps.

18. Employers must provide laundering of protective garments used for standard precautions at no cost to employees. Contaminated laundry should be handled as little as possible without sorting or rinsing. All soiled linens should be bagged where they are used in a color-coded bag clearly indicating requirement of universal precautions.

Emergency and Exposure Incident Plan

An emergency and exposure incident plan must be developed for employees. A separate plan is needed for students if they use different medical care resources or methods for reporting exposure incidents. A program coordinator who will be the contact person when emergencies arise should be identified. That individual also may become the trainer for office personnel. The OSHA has mandated an exposure incident plan that emphasizes documentation of incidents and their follow-up. During training sessions, personnel must be instructed on what needs to be done in an emergency, but documenting a plan of medical emergency care is an equally important aspect of employee protection. Five requirements of an incident plan should be addressed:

1. Exposures to mucosa may not be associated with an injury, or an exposure incident may involve minor or severe injury (e.g., from a cutting instrument). Rapid
and thorough cleaning of a wound or washing a splashed eye or mouth as quickly as possible is the most important first step to minimize infection risks. Blood tends to collect on the surface of puncture wounds created by solid pointed instruments, so washing puncture wounds is just as important. Specific staff members to provide any help, direction, or transportation needed to obtain medical care must be identified. A brief written plan for accessing rapid medical attention should be formulated. This content should constitute the first part of the exposure incident plan. Sufficient time will still be available for a designated responsible individual to contact the patient and transmit medical records and other information to the attending physician, as presented next.

2. The written permission of the patient who is the source of exposure must be obtained to copy and convey his or her medical history to the attending physician or to obtain other medical records regarding the patient. Knowledge of risk behavior, blood test results, or other pertinent information usually can be conveyed verbally in confidence, however, without permission in case of exposure. Local laws must be consulted. Some states only prescribe communication of the name, address, and phone number of the patient and the name and phone number of the patient’s physician to the attending physician of the exposed individual. The examining physician will contact the patient’s physician, who will then deal with testing the patient.

3. As directed by OSHA regulations, employers must provide a copy of the exposure incident plan and explain it to the employees. Employers must document the route and circumstances of the exposure, identifying the source patient when possible. Employers must provide and pay for exposure incident evaluation and follow-up evaluations for an exposed employee, or these may be paid for by workers’ compensation.

4. If other local regulations do not exist, employers also must (a) identify and contact the source patient if possible; (b) obtain the source individual’s permission to be tested, unless he or she already is known to be infected; (c) have the source individual’s blood tested by a health care professional, as soon as feasible, for evidence of current HIV or HBV infection (e.g., if blood is available, some states permit testing without permission in exposure instances); (d) provide results to the exposed employee in confidence (state laws often require counseling of the source patient and the exposed individual for HIV testing); (e) test the employee’s blood, with his or her permission, as soon as feasible; (f) hold any available sample of the employee’s blood for 90 days if consent is not given for HIV testing to provide for any change of mind; and (g) provide post-exposure prophylaxis to the employee, when medically indicated, according to recommendations of the U.S. Public Health Service.

5. The attending physician must be provided with a copy of OSHA regulations (from which this information is taken), documented information regarding the incident, results of the source individual’s tests, and the employee’s immunization records and any other relevant medical records.

6. A written report from the attending physician must be obtained by the employer and provided to the employee within 15 days of the completion of evaluation, stating that the employee has been informed of the results, possible infection consequences, and any further evaluation or treatment needed that relates to the exposure incident. Unrelated diagnoses or findings remain confidential.

Training of Personnel Required by Occupational Safety and Health Administration

Occupational safety guidelines require that new office personnel who will have contact with blood and blood-contaminated body fluids receive initial training in infection control. Retraining is required annually and whenever the exposure control protocol changes. Training of personnel must contain the following elements, as listed in the OSHA standard:

1. An accessible copy of the regulatory text of this standard and an explanation of its contents
2. A general explanation of the epidemiology and symptoms of blood-borne diseases
3. An explanation of the modes of transmission of blood-borne pathogens
4. An explanation of the employer’s exposure control plan and the means by which employees can obtain a copy of the written plan
5. An explanation of the appropriate methods for recognizing tasks and other activities that may involve exposure to blood and other potentially infectious materials
6. An explanation of the use and limitations of methods that would prevent or reduce exposure, including appropriate engineering controls, work practices, and PPE
7. Information on the types, proper use, location, removal, handling, decontamination, and disposal of PPE
8. An explanation of the basis for selection of PPE
9. Information on the HBV vaccine, including information on its efficacy, safety, method of administration, benefits of being vaccinated, and that the vaccine and vaccination will be offered free of charge
10. Information on the appropriate actions to take and persons to contact in an emergency involving blood or other potentially infectious materials
11. An explanation of the procedure to follow if an exposure incident occurs, including the method of reporting the incident and the medical follow-up that would be made available
12. Information on the postexposure evaluation and follow-up that the employer is required to provide for the employee after an exposure incident
13. An explanation of the signs and labels or color coding required by the OSHA standard
14. An opportunity for interactive questions and answers with the individual conducting the training session
15. Additional specific information must be provided regarding the details and cleanup schedules for employees’ operatory and facilities.
Occupational Safety and Health Administration—Required Records

Job classification and immunization and medical records of personnel must be kept for 30 years by the office or a designated physician for OSHA inspection or disposed of, according to requirements. Training records must be kept for 3 years from the date of training. Exposure incidents must be tabulated and posted according to OSHA requirements. Details are provided in the regulations. An interpretation of these regulations for dentistry has since been published. Some variations from these and other OSHA regulations may be specified later for dentistry as a result of petitions made by the ADA. The dentist should consult current information.

Regulations of Other Agencies

State public health services and dental licensing boards complete the spectrum of infection control regulatory agencies. Most agencies specify the infection control guidelines of the ADA and the CDC of the U.S. Public Health Service, but focus more on tasks and procedures necessary for patient protection in dentistry.

Regulations Regarding Infected Health Care Personnel

Concerns about the possible transmission of AIDS from infected health care personnel to patients has led the U.S. Public Health Service to recommend additional precautions. All health care personnel who perform invasive, exposure-prone treatments are urged to obtain testing for HBV and HIV infections voluntarily.

Exposure-prone procedures include simultaneous use of the operator’s fingers and sharp instrumentation in a highly confined or poorly visualized anatomic site such as the mouth, where tissues are cut or bleeding can occur. Clinical personnel are considered infected when they test positive for antibodies against HIV or for hepatitis B surface antigen (HBsAg) and hepatitis B core antigen (HBcAg). Infected health care personnel are advised not to perform exposure-prone procedures unless they have sought counsel from an expert review panel and have been advised under what circumstances they may continue to perform these procedures, depending on the experience and skill of the clinician involved. As defined by the CDC, a review panel may consist of the worker’s physician, an infectious disease specialist with expertise in the epidemiology of HIV and HBV transmission, another health care professional with expertise in the type of procedures performed, and a local public health official.

Occupational Safety and Health Administration—Required

Acquired Immune Deficiency Syndrome and Human Immunodeficiency Virus Infection

AIDS is the last stage of a debilitating, eventually fatal human disease. AIDS may develop in 1.5 to 11 or more years after an initial infection with HIV. HIV is a relatively fragile ribonucleic acid (RNA) retrovirus, which is easily destroyed in the dry state in 1 to 2 minutes by most disinfectants.

Human Immunodeficiency Virus: Epidemiology and Transmission

Since its recognition in 1981, as of the end of 2006, HIV had infected 1.1 million people in the United States, with 21% going undiagnosed. HIV is transmitted mainly through blood, blood-contaminated bodily fluids such as semen, and vaginal fluids. High-risk behaviors or situations that define high-risk groups include having multiple sex partners of the same or opposite sex; having a sexual partner who is at high risk or infected; intravenous drug abuse; treatment for hemophilia; blood transfusion received before spring 1985; and infants of an infected mother. Casual, nonsexual contact, including social kissing and sharing towels or food among family members in a household with an AIDS patient, has not been shown to transmit the infection.

Progression of Human Immunodeficiency Virus Infection into Acquired Immune Deficiency Syndrome

After a prolonged quiescent state of 1.5 to possibly 11 years after infection, HIV begins to destroy cells that control the normal immunity of the body against infections and tumors. At that time, the body becomes more and more vulnerable to many common viruses and microbes found in the normal environment. Commonly harmless parasites and fungi are able to cause severe and often fatal conditions such as pneumonia and cerebral infections.

On entering the blood or tissues, HIV can attach only to certain docking sites that it finds projecting from the surfaces of certain white blood cells. Helper lymphocytes crucial to the normal functioning of the immune system are covered with these sites. Immunologists have labeled these cells T helper lymphocytes because the thymus has an important role in preparing them to function. The surface attachment sites are termed category designation four (CD4) glycoprotein antigens. When it becomes attached, virus RNA can enter and infect the lymphocyte.

The cells commonly infected, termed T4 (CD4) helper lymphocytes, are crucial to normal cellular and antibody functions that protect humans against many bacteria-infected, fungi-infected, and virus-infected cells and tumors or cancers. Other cells such as macrophages, neurologic glial cells, colon or rectal cells, and possibly some connective tissue cells also have the CD4 glycoprotein surface sites to which HIV can attach itself. Colon cells (e.g., in the case of male homosexual intercourse) may serve as infection sites. It is unknown whether the mucosal cells of other body cavities may serve as initial infection sites as well. Various susceptible cells and perhaps the cells in bone marrow may serve as reservoirs of the virus in a prolonged latent or quiescent incubation stage when HIV sometimes cannot be detected in blood.

HIV is termed an RNA retrovirus, which needs complementary DNA formed within the nucleus of a host cell (termed provirus form) to reproduce the HIV. As HIV gains entry into the lymphocytes, reverse transcription of viral RNA begins, resulting in the formation of double-stranded viral DNA in
the infected cells. When inserted into the cell's genetic structure (genome), this DNA becomes the provirus of HIV. The DNA of HIV may divide and reproduce along with the cell's nuclear DNA for years. Antibody tests are now available to detect the provirus DNA fragments that regulate the production of various parts of the HIV structure (i.e., core proteins, gag; viral envelope, env; reverse transcriptase, pol). After remaining latent during the prolonged incubation period in infected helper lymphocytes, HIV begins to replicate. The lymphocytes die, releasing the virus into blood, and the numbers of essential helper lymphocytes are drastically reduced. When helper cell counts decrease to less than 200/mm³ in blood, many different opportunistic infections and tumors appear. Conditions are such that it becomes increasingly difficult to treat the patient until fatal Pneumocystis infection of the lungs occurs, or until HIV or other infection of the brain causes death. Levels of virus in blood usually increase at this time but are still low compared with the huge viral concentrations reached in the blood of patients with HBV. At our institution, patients with T4 helper cell counts of 200/mm³ or less benefit from the protective facilities, nursing care, and treatment expertise offered by the hospital dental service clinicians.

Symptoms and Oral Manifestations
Within 3 months of infection, temporary flu-like symptoms—pharyngitis, myalgia, fatigue, fever, or diarrhea—may occur when antibodies to HIV become detectable. Following the prolonged incubation of the virus for approximately 1.5 to 11 years, any of several early signs of AIDS that signal the progressive failure of the immune system may be observed by the dentist. During examination, the dentist can easily detect one or two cervical lymph nodes, especially below the mandible, that persist for more than 3 months. The nodes may be attached and painless, or they may be movable, painful, and infected. Undifferentiated non-Hodgkin's lymphoma may arise in lymph nodes or may appear in the mandible, central nervous system, eyes, bone marrow, and other vital organs.

Persistent oral candidiasis is often seen with easily dislodged, white, curd-like patches scattered over the tongue. In AIDS, such infection may not respond easily to treatment and often recurs, developing into atrophic candidiasis or cheilitis at the angles of the lips. Painful herpes stomatitis also is common. Untreated herpes or candidiasis may progress to esophagitis or laryngitis, impairing speech.

Red, brownish-to-purple blotches that persist on the oral mucosa and skin typify sarcoma of the capillaries, termed Kaposi's sarcoma. Oral lesions often develop into tumors that may require surgery and radiation therapy. Kaposi's sarcoma often is found on the oral tissues of homosexual men. Human papillomavirus (HPV) can cause oral warts that appear flat or cauliflower-like.

Serologic testing for the virus and provirus DNA also has been developed. Tests for T4/T8 (or CD4/CD8) lymphocyte ratios are used to identify the progress of the HIV infection. One criterion for starting zidovudine therapy is a T4 helper cell count less than 500/mm³ of blood.

SeroLOGY OF HUMAN IMMUNODEFICIENCY VIRUS INFECTION
HIV infection is detected with blood tests (enzyme-linked immunosorbent assay [ELISA], Western blot test, and fluorescent antibody test) that detect antibodies formed against the virus. Tests for anti-HIV antibodies are often positive within 3 months after infection. Most are positive by 6 months; in 1% of cases, it takes 12 months to obtain a positive test. A second positive test is necessary to confirm positive serologies. Serologic tests for the virus and provirus DNA also have been developed. Tests for T4/T8 (or CD4/CD8) lymphocyte ratios are used to identify the progress of the HIV infection. One criterion for starting zidovudine therapy is a T4 helper cell count less than 500/mm³ of blood.

HUMAN IMMUNODEFICIENCY VIRUS RISKS FOR CLINICAL PERSONNEL
Of all American health care workers injured by needles and sharp instruments used to treat HIV-infected persons, only 0.3% or less have become infected with HIV. This statistic contrasts with 30% of workers who become infected with HBV after parenteral exposure to infected blood. As of December 2006, among all U.S. health care personnel, documented occupation-related HIV infections total 57, of which none was reported among dental personnel.

As was pointed out at the beginning of this chapter, dental personnel have been spared, almost miraculously, being infected with HIV. Thousands of unprotected dentists who unknowingly treated HIV-infected patients must have been exposed to HIV as the epidemic mounted during the 1980s before gloves and other barriers came into common use. Only six dentists who claim no other exposure risks seem to have acquired HIV infection by occupational exposure. Testing at the time of exposure for evidence of prior HIV infection was not commonly performed in dentistry until the 1990s. Because none of the infected dentists had such baseline blood tests, their HIV infections cannot be linked firmly to the time and circumstance of clinical exposure.

HIV infection was reported to have developed in a nurse and a technician who were spattered with HIV-infected blood. Other medical personnel have been reported to have acquired HIV infections related to spatter of infected blood on their nonintact skin. The serologic status of HIV in these persons was apparently not known when they were exposed. Personnel are required to protect their eyes, mucosa, skin, and hands from spatter and direct contact with blood and blood-contaminated bodily fluids during dental treatments of all patients. Precautions also must be taken to minimize risks of injuries with sharp instrumentation.

Patients seriously ill with AIDS who are seen in a hospital setting also may harbor transmissible respiratory infections such as tuberculosis and cytomegalovirus (CMV) infection. As indicated in the section on the epidemiology of other infection risks, transmission of drug-resistant tuberculosis from immunocompromised patients is a growing threat.
Human Immunodeficiency Virus risks for Dental Patients

With proper use of infection control measures in dental practice, the risk for a dental patient of contracting HIV from office personnel or from other patients is extremely low. HIV has not been transmitted to dental patients from infected clinical personnel anywhere in the United States, with the exception of one unique outbreak. In a circumstance that has been unique as of 2011, six patients were found to be infected with the same strain of HIV present in a Florida dentist who had treated them. These patients had no apparent source of exposure other than the dentist who, in spite of having AIDS symptoms, continued to treat patients. This dentist’s use of adequate infection control measures was questionable. It is quite likely that some kind of clinician-to-patient transmission had occurred in this case. At this time, no other instances of transmission of HIV from infected dentists or physicians to patients have been reported. One or more alleged HIV cross-infections between patients, attributed to contaminated dental equipment, are under investigation.

Human Immunodeficiency Virus Data Related to Infection Control

Data that provide a better understanding of disease agents, their survival qualities, and clinical transmission potentials help clinicians institute effective infection control. The following HIV data are reassuring and help explain the amazingly low occupational risk of HIV infection for dental personnel:

1. In contrast to HBV, very low levels of HIV usually have been found in the blood of infected persons. This is especially true of asymptomatic persons, who are the most difficult to recognize and would be most likely to be treated in private clinics.
2. HIV was detected in only 28 of 50 samples of blood from infected persons. In saliva from infected persons, HIV was detectable in only 1 of 83 samples. Counts of virus per milliliter of blood fluctuate but may increase as the number of antibodies to the HIV core protein decline.
3. CDC investigators have found 99% of HIV to be inactive in approximately 90 minutes in dried infected blood. Longer survival data on larger numbers of HIV grown in laboratory cell cultures have created misleading information about the survival of HIV in dried infected blood. In blood that remains wet, however, the virus may survive for 2 or more days. Caution is required when handling containers of used needles in which virus-infected blood may remain wet.
4. HIV is killed by all methods of sterilization. When used properly, all disinfectants, except some quaternary ammonium compounds, are said to inactive HIV in less than 2 minutes.
5. HIV has been transmitted through blood-contaminated fluids that have been heavily spattered or splashed on persons. Aerosols such as those produced during dental treatments have not been found to transmit HBV or HIV infection.
6. Barriers have proved successful in protecting dental personnel in hospital dentistry and in all other dental clinics against HIV; at our institution, for more than 10 years, they have been providing effective prevention of even more easily transmissible viral infections.

A more recent concern for immunocompromised individuals and for dental personnel is airborne transmission of multidrug-resistant Mycobacterium tuberculosis.

Viral Hepatitis: Agents, Epidemiology, and Infection

In the 8 years after AIDS was recognized, 38,000 persons were identified to have developed the disease. During that same period, an estimated 38,400 persons died from HBV, related cirrhosis, or liver carcinoma. Infective inflammation of the liver, termed hepatitis, can be caused by infection from various hepatitis viruses labeled A to G. The type of infection is diagnosed specifically by serologic testing. Hepatitis types A, B, and C are roughly equally divided among cases of viral hepatitis detected in population surveys, with hepatitis A virus (HAV) being the most prevalent. HBV, HCV, and HDV are blood-borne infections. HAV and HEV are fecal-borne infections. A new blood-borne virus, HGV, has been detected in a group of high-risk hospitalized dental patients with liver disease associated with other viral agents or conditions. The importance of HGV and its contribution to liver disease are unclear.

HBV is found in 1 in 100 to 500 persons in the general population (estimated 1.2 million people with chronic infection in the U.S.), including dental patients. The incidence has peaked in areas associated with high rates of intravenous drug abuse and closely follows the incidence of HIV infection. According to the CDC, 1 in 55 persons (1.8%) in the U.S. population may carry HCV, with an estimated 3.2 million people with chronic HCV infection. HCV accounts for one third of liver transplantations and more than 8000 deaths per year.

Viral Hepatitis Infection: Symptoms, and Clinical Findings

HBV must enter the circulating blood to reach the liver, where the viral DNA causes infected hepatic cells to reproduce the virus. Symptoms usually appear after 2 to 4 months of incubation. Extensive liver damage and illness occur rapidly in approximately 2 of 10 infected persons. Symptoms and signs include nausea, vomiting, chronic fatigue, mental depression, fever, joint pain, darkened urine, jaundice, elevated liver enzymes, and possibly diarrhea or rash. Mortality is 2% or less but tends to be 2% or greater in individuals older than 30 years of age. CMV and Epstein-Barr virus (EBV) infections also may produce jaundice and elevated liver enzymes.
Only 2 of 10 individuals infected with HBV show symptoms. The other 8 individuals are usually unaware of their infection. For this reason, it is impossible to detect most HBV-infected individuals from medical history. Whether or not the infected individuals are symptomatic, they can transmit HBV. Usually, within 1 year, 9 of the 10 individuals develop immunity to HBV and are no longer infectious. Of the 10 infected individuals, 1 remains infected and infectious, often for the remainder of life. Acute cirrhosis may be fatal within months. If the illness was not severe and chronic infection persists, increased risk of cirrhosis or hepatocellular carcinoma may prove fatal in 20 to 30 years. The possibility of such an outcome results in an overall hepatitis mortality rate of 2%. No specific treatment against the virus is available once the infection has occurred.

Other types of hepatitis produce symptoms similar to those of HBV.22,25,67,68 HAV has a shorter incubation of approximately 1 month and lower mortality. Individuals infected with HAV do not remain infected or infectious beyond 8 weeks after symptoms subside. HCV is often (75%) anicteric (without jaundice), and elevated levels of liver enzymes and serologic tests help establish the diagnosis. HCV becomes chronic in 75% to 85% of the infected individuals, causing them to remain infectious.51,71 HDV, or delta hepatitis virus, has a curious makeup. It has no outer coating and relies on the cells infected with HBV to provide the required outer layer. When HBV and HDV infect an individual concurrently, usually by the same route and source, the infection becomes much more severe and many times more fatal than infection with HBV alone. Protection against HBV also protects against HDV, but not HAV, HCV, or HEV.66-68

Transmission of Viral Hepatitis

The transmission of HBV, HCV, and hepatitis D virus is mainly through blood, intravenous drug abuse, and sexual contact. Billions of HBV may be present in one milliliter of infectious blood.6 HBV also is found in saliva, but at lower concentrations. HBV can be transmitted through contamination of broken skin, the mouth, or the eyes with blood-contaminated saliva. One in three nonvaccinated exposed persons may be infected with HBV. In studies performed during dental treatments of HBV-infected individuals, aerosolization of HBV could not be detected with tests for HBsAg.65 HBV is transmitted in the population through the same routes as those for HIV infection. In contrast to HIV, however, HBV has been transmitted to family members through prolonged associations that may involve repeated contamination with saliva or blood (e.g., through sharing of shaving instruments, traces of blood left on bathroom towels, continuous sharing of unwashed toothbrushes, or drinking from the same cup). In public situations, neither HIV nor HBV is transmissible through contaminated food and water are common routes of infection.

HBV is excreted from the infected liver into bile. HAV and HEV are is excreted from the infected liver into bile. HAV and HEV are

Serologic Tests Related to Hepatitis A, B, and C Viruses

Serologic tests are available for the detection of the several antigens of HBV and for the serum antibodies individuals produce against them.29,67 Testing a blood sample for HbsAg can determine the presence of infection by detecting the protein associated with the surface of the HBV in blood. The test is used to identify individuals who are infected, whether or not they are symptomatic. Testing for HBeAg determines presence of an HBV antigen found in blood when HBV concentrations are high and relate to the individual’s ability to infect others.

Testing for the antibody against the HBV core antigen (anti-Hbc) can detect the antibody against a virus core protein that becomes positive in virtually all individuals a few months after infection and remains positive for years thereafter. The antibody is used as a marker for previous HBV infection, but this antibody is not protective. A test for anti-HBV surface antigen (anti-HBs) is performed to determine the presence of antibodies that can protect against future HBV infection. Detection of anti-HBs means that the individual has been infected and has recovered or has been immunized with a vaccine.

Data Related to the Control of Hepatitis B Virus

HBV is a relatively stable DNA hydrophilic virus that can withstand drying on surfaces and presumably on equipment
and clothing for more than 7 days.76 One billion virus particles of HBV can be found per milliliter of infected blood. Disinfectants selected for their ability to inactivate tuberculosis and hydrophilic viruses seem to be able to inactivate HBV.77,78 All forms of sterilization destroy the virus.578

**Immunization Against Hepatitis A, B, and C Viruses**

An effective vaccine against HAV has been developed and is recommended for the dentist, dental student, and auxiliary personnel.11,79,80

Vaccination against HBV requires one dose followed by a second dose 1 month later and a third dose 6 months after the first. Hepatitis vaccines must be given in the arm. Protection of individuals who form antibodies is virtually 100%. One in 30 individuals vaccinated may not respond to the vaccine. Follow-up testing is recommended by the CDC to confirm immunity 1 month after immunization is completed because dental personnel are considered to be at high risk for HBV infection.1,7,67 Protective immunoglobulin is available for HBV-exposed individuals who have no immunity. No vaccine is available against HCV. Because the virus mutates rapidly in infected individuals, a vaccine may be difficult or impossible to develop. No protective immunoglobulin is available for exposed individuals.71

**Tests for Hepatitis B Antibody and Boosters**

After a period of 1 to 6 months after the vaccination against HBV is completed, it is important that dental personnel obtain a test to determine if protective anti-HBs were formed.1,7,67 One or more of 30 vaccinated adults younger than 40 years of age may not respond to three vaccine injections. Higher percentages of individuals older than 40 years do not respond because the immune response gradually diminishes with age.67 Routine boosters are not recommended for the general health care profession by the CDC.1,12,51,67,81-83 A booster effect usually is experienced by an infected individual who has produced antibodies. In dentistry, because of the crisis situation that can surround an exposure, the time it takes to obtain test results after an exposure, and the frequent problem of never knowing when a small exposure has occurred, dental personnel often prefer to have their blood tested with a radioimmunoassay test for anti-HBs to check their immunity. If test results are less than 10 serum ratio units, they should take a booster dose of the HBV antigen. This is in keeping with the recommendation for receiving a booster dose when exposure is known to have occurred and antibodies in a previously immunized individual are deficient.67

**Epidemiology of Other Infection Risks**

Several agencies want to ensure that dental personnel and patients are protected against risks of all infections borne by blood, saliva, and respiratory secretions. Routine medical histories are important but cannot be relied on to detect infected patients or for selective use of “standard precautions” for individual patients. All patients must be considered infectious. In addition to HIV, HBV, HCV, and HDV (discussed previously), other transmissible infections of concern include infectious mononucleosis (EBV infection), CMV, herpes simplex virus 1 and 2 (HSV 1 and HSV 2), and tuberculosis.11,14,61,84 Without barrier protection, dental personnel’s hands and the mucosa of the eyes and mouth are especially vulnerable to infection with herpes viruses.5,44,48,85,86 Agents of measles, mumps, other childhood infections, and some other respiratory infections also are transmissible, especially in indistinguishable early stages of infection.57,84 Measles and mumps can be severe in adults (Online Fig. 19-7). In 1990, 23% of measles infections occurred in individuals older than 19 years of age. The mortality rate was 0.3%; one third of fatal cases involved nonimmunized adults.84 Measles outbreaks among college students have been severe.87

Multidrug-resistant tuberculosis bacteria are an increasing concern.60 These bacteria are resistant to two or more of the more common therapeutic drugs and are highly transmissible through aerosols produced by coughing. Infections seldom become active in healthy adults, but an active infection can remove a clinician from practice for months until the infection is controlled and is no longer transmissible. Infection with multidrug-resistant tuberculosis can be rapidly fatal for immunocompromised individuals.60

CMV infection, a disease that is transmitted through sexual contact and blood, is not commonly known and often resembles infectious mononucleosis. Especially during pregnancy, a newly infected woman faces the risk of possible intrauterine or perinatal infection of her infant. Developmental defects can occur in 5% to 10% of infected infants, resulting in neuromuscular, auditory, and visual impairments.78 CMV is just another infection to which personnel in the dental operatory are susceptible, but it can be prevented by universal use of barrier protection.

Personnel should receive immunizations against measles, polio, and tetanus. Annual or semi-annual skin tests for tuberculosis (purified protein derivative) are recommended by the CDC for dental personnel.11 HBV immunization is mandated by federal OSHA, unless an employee documents his or her understanding of the risks and his or her refusal. Measles vaccination is required for individuals born after 1956, or they must show proof of immunity for admission to most colleges.88 This is also an important requirement for dental personnel.

Immunizations against viral influenza and pneumococcal pneumonia are advisable. Mumps immunization is highly desirable for both male and female personnel without a history of immunization or childhood infection. Diphtheria and pertussis immunizations usually are received during infancy. Development of vaccines to prevent HIV, HCV, and other common infections is an ongoing process.71

**Exposure Assessment Protocol**

The OSHA does not regulate students, but dental students are required to follow the same exposure incident protocol plan as do dental employees, but the appropriate differences for students such as the source of medical care should be taken into consideration.30,36 This plan requires that if blood-contaminated bodily fluid from a patient is spattered onto the mucous membranes or comes into contact with the broken or
Online Fig. 19-7 Oral manifestations associated with communicable diseases. **A**, Primary herpetic gingivostomatitis. (Courtesy of Dr. William F. Vann, University of North Carolina, Chapel Hill) **B**, Herpes labialis (gingival mucosa). **C**, Herpes labialis. (Courtesy of Dr. Lauren Patton, University of North Carolina, Chapel Hill) **D**, Herpetic whitlow, index finger. (Courtesy of Dr. James Crawford, University of North Carolina, Chapel Hill) **E**, Chicken pox, rash on the trunk. (Courtesy of Dr. William F. Vann, University of North Carolina, Chapel Hill) **F**, Chicken pox, gingival lesion. (Courtesy of Dr. William F. Vann, University of North Carolina, Chapel Hill) **G**, Herpes zoster (shingles, supra-orbital dermatome distribution). (Courtesy of Dr. Diane C. Shugars, University of North Carolina, Chapel Hill) **H**, Condylomata acuminatum, or venereal wart. (Courtesy of The Centers for Disease Control and Prevention, Atlanta)
punctured skin of a clinician or if exposure has occurred through a cut or puncture with a contaminated sharp instrument, the protocol must be followed immediately, before the patient leaves. If possible, the patient’s potential to transmit HBV, HCV, and HIV is determined, as is the student’s susceptibility to HBV. The attending physician who helps with these determinations provides, if indicated, HBV immunoglobulin, hepatitis booster, anti-HIV testing, and counseling (see the section on OSHA regulations).89

**Medical History**

The medical history serves the following purposes: (1) to detect any unrecognized illness that requires medical diagnosis and care; (2) to identify any infection or high-risk behavior that may be important to a clinician exposed during examination, treatment, or cleanup procedures; (3) to assist in managing and caring for infected patients; and (4) to reinforce the use of adequate infection control procedures, bearing in mind that general history taking cannot help detect all infectious individuals. Only the conscientious use of standard precautions ensures safety. Symptoms of persistent respiratory illness, night sweats, chronic fatigue, and weight loss can be symptomatic of either tuberculosis or HIV infection. With the increasing occurrence of multidrug-resistant tuberculosis bacteria, the medical histories of HIV-infected dental patients and others at high risk should be kept updated with information on current medical care and surveillance from the patient’s physician. The clinician should be aware of the relationship of all infections (and their characteristics) when taking medical history and performing an initial general examination at each appointment.

**Personal Barrier Protection**

**Gloves**

OSHA regulations specify that all clinical personnel must wear treatment gloves during all treatment procedures. After each appointment, or whenever a leak is detected, gloves are removed, hands are washed, and fresh gloves are donned (see Online Figs. 19-5 and 19-6). Gloves must not be washed or used for more than one patient. Inexpensive, disposable, well-fitting treatment gloves are available for chairside use. Used gloves should be disposed of carefully to avoid contaminating others in the box. The value of using gloves was emphasized by the finding that without gloves, occult blood persists under dentists’ fingernails for several days after patient contact.89 Gloves also help prevent painful and transmissible herpetic infections to fingers (whitlow) and hands.74,90

Gloves must not be washed. Washing reduces the integrity of the glove, leaving personnel more vulnerable. Instead of attempting to wash gloved hands before opening drawers or handling items adjacent to the operatory, tongs, a
paper towel, or a food handler’s overglove should be used to prevent contamination.

Dental personnel with chronic HBV or HIV infection should avoid any treatment activities that would jeopardize the patient. All personnel with weeping or draining lesions that could infect patients should abstain from patient contact.1,3,2 Dry, non-draining lesions should be kept well protected from clinical contamination.

Increased marketing competition has reduced the prices of gloves and has improved the quality of latex gloves appreciably. Penetration by viruses has been found to occur in only 1 of 100 intact latex gloves.91 Gloves must meet the U.S. Food and Drug Administration (FDA) regulations: The allowed leak rate detectable with a water test is less than 4%.92 Some companies have set even higher standards, at less than 2% to 3%. Boxes of gloves should be stored away from sunlight, and multiple boxes should be stored in tightly closed, heavy plastic bags to minimize oxidation. If any doubt exists about a supplier’s gloves, the distributor should be contacted to verify adherence to FDA regulations and the manufacturing standards of the product. Products that do not meet FDA standards and advertising claims are subject to removal from the market if consumers report lack of compliance.

While cleaning and sorting used sharp instruments, puncture-resistant utility gloves should be worn. Nitrile latex gloves are preferable; they can be washed inside and out, disinfected, or steam autoclaved, as needed. Treatment gloves, if they must be shared, should be worn inside heavy gloves. With the current practice of wearing latex gloves for several hours each day, dental personnel should be aware that the possibility of latex allergy or hypersensitivity is a growing concern for all personnel and patients. In July 1991, the FDA requested that all cases of allergic reactions to latex be reported. The concern among dental health care workers is based on the frequent changes of gloves, which exposes them to the latex protein allergens. The symptoms associated with latex allergy or hypersensitivity should not be confused with the physical irritation caused by frequent handwashing. Currently, no cure for latex allergy exists. Avoidance of latex-based products is the best treatment.

Instructions for Handwashing
At the beginning of a routine treatment period, the clinician should remove his or her wristwatch, jewelry, and rings (or at least those with enlarged projections or stones that can penetrate gloves), then wash hands with a suitable cleanser. Hands should be lathered for at least 15 seconds, rubbing all surfaces, and rinsed. A clean brush should be used to scrub under and around nails. Washing should be repeated at least once to remove all soil. Washing hands well when changing gloves is mandatory.91,95 Even good-quality surgical gloves develop minor pinholes or leaks during vigorous use. Washing minimizes infection risks secondary to leakage. Before surgery, the clinician should use a prescribed surgical scrub and wash and rinse from the hands toward the elbows. A separate brush should be reserved to clean the instruments.

Hand cleansers containing a mild antiseptic, such as 3% parachlorometaxylenol (PCMX) or chlorhexidine, are preferable for controlling transient pathogens and for suppressing overgrowth of skin bacteria.94 Hand cleansers with 4% chlorhexidine may have broader activity for special cleansing (e.g., for surgery, when a glove leaks, or when a clinician experiences an injury), but they can be hazardous to eyes.91,95 PCMX cleansers have been found equally effective, nonirritating, and preferable for routine use.95 Newer non-opaque chlorhexidine products used especially for surgical scrubs may be less irritating to the hands of some individuals for prolonged use.96 Additionally, proper use of alcohol rubs is effective against pathogens and less drying to the hands.1

Protective Eyewear, Masks, and Hair Protection
Protective eyewear may consist of goggles or glasses with solid side-shields. A mask should be worn to protect against aerosols. Face shields are appropriate for protection against heavy spatter, but a mask still is required to protect against aerosols that drift behind the shield.9,34 Spatter also can pass under the edge of a short shield and strike the mouth. Anti-fog solution for eyewear can be obtained from opticians or product distributors.

The clinician should put on eyewear with clean hands before gloving and remove it with clean hands after the gloves are removed. Eyewear should be grasped by the temple pieces. The clinician should grasp the mask only by the string or band at the sides or back of the head to remove it (Online Fig. 19-8). The mask should be changed between every patient or whenever it becomes moist or visibly soiled. When the patient is dismissed after treatment, the mask should be discarded and not worn around the neck, as the contaminated edges can rub against the neck. Touching masks and eyewear during treatments should be avoided to prevent cross-contamination. When eyewear or shields are removed, they should be cleaned and disinfected. To save time, clean replacement eyewear should be readily available while used eyewear is being disinfected. If preferred, goggles that can be autoclaved are available from dental distributors.

Online Fig. 19-8 Remove the mask as shown. Grasp the mask ties or elastic band behind the head instead of grasping the contaminated mask. Before treatment, put on mask and eyewear before washing and gloving hands. After treatment, remove gloves and then eyewear and mask, and wash hands.
Masks with the highest filtration are rectangular, folded types used for surgeries. Dome-shaped masks are adequate barriers against spatter and are considered effective in preventing HBV and HIV infections; however, they are not adequate to hold back measles, influenza, and other aerosol-borne respiratory viruses or tuberculosis bacteria. To protect against aerosols, the edges of the rectangular mask should be pressed close around the bridge of the nose and face. Masks have been rated according to their porosity and effectiveness. The claims and test data of mask manufacturers should be consulted and compared before choosing a mask.

Operatory personnel should keep their hair out of the treatment field. Hair can trap heavy contamination that, if not washed away, can be rubbed back from a pillow onto the face at night. Hair must be protected with a surgical cap when the possibility of encountering heavy spatter (e.g., from an ultrasonic scaling device) exists.

**Protective Overgarments**

An overgarment must protect clothing as well as skin (see Online Fig. 19-4). Used overgarments should be only minimally handled and laundered or disposed of properly. Overgarments must be changed whenever they become wet or visibly soiled. Operatory clothing is heavily spattered with invisible saliva and traces of blood throughout the day. HBV and many other microbes can live on dry materials for 1 or more days. The upper surfaces of the wrists and forearms can be contaminated by heavy spatter. Spatter remains on uncovered arms most of the day if not protected by long sleeves. The large cuffs of the clinic coat sleeves may brush against patient napkins and mouths, become grossly contaminated, and cross-contaminate patients. Sleeves with knit cuffs that tuck under the gloves are preferable. If not covered, arms must be washed after each patient if any spattering occurred. Most office sinks are not deep or wide enough for effective, routine arm washing.

A simple, lightweight garment that covers the arms and chest up to the neck and the lap when seated may provide adequate protection. Cloth made of cotton or cotton–synthetic fiber similar to isolation garment material may be thick enough to protect skin and street clothing from spatter during most dental treatments. If surgery or other treatment produces splashing that wets a garment, the clothing should be changed as soon as possible, and the skin should be cleaned.

Contaminated garments should not be worn after leaving the clinical area. Such garments can contaminate family members who sort, handle, and launder soiled clothing or may infect young children who may come in contact with adults’ clothing (e.g., hugging the parent who has come home from work). Contaminations with HBV, tuberculosis, and respiratory viruses (e.g., respiratory syncytial virus) are of most concern.

Before leaving the clinical area, used overgarments are removed and placed directly into a laundry bag with a minimum of handling or sorting. Guidelines call for managing used clinic garments to avoid handling or sorting (e.g., searching pockets, removing name tags). Persons handling soiled clinical garments must wear protective gloves. Laundering must be provided by the employer.

Laundering with a regular cycle with regular laundry detergent is considered acceptable, following manufacturer’s directions. Hot water (70°C or 158°F) or cool water containing 50 to 150 parts per million (ppm) of chlorine provided by liquid laundry bleach would provide additional antimicrobial action.

**Disposal of Clinical Waste**

Infected blood and other liquid clinical waste, except mercury, silver, or other heavy metal chemicals, generally can be poured down a sanitary sewer or drain designated for that purpose. Application of aseptic precautions and cleaning and disinfection of the basin around the drain must be performed. Contaminated materials such as used masks, gloves, blood-soaked or saliva-soaked sponges, and blood-soaked or saliva-soaked cotton rolls must be discarded safely. OSHA regulations presented previously describe the rules and required labels with regard to disposal of sharps and soft waste. OSHA labeling requirements may differ from local protection agency requirements. As pathologic waste, excised tissues require separate disposal and should not be discarded into the trash.

Care must be exercised in bagging medical waste so that injury or direct contact with liquids does not occur, as HIV and HBV can survive beyond a few days in wet blood. Separating needles and sharps into hard-walled, leak-proof, and sealable containers and out of soft trash has been shown to provide adequate safety. Nevertheless, local laws governing waste disposal range from the recommendations of the CDC to regulations requiring stricter management and tracking of waste disposal, usually at an added expense. Local city, county, and state regulations should be consulted.

**Needle Disposal**

The goals with regard to needle disposal are (1) disposing of needles in a hard-walled, leak-proof, and sealable container, which has the OSHA biohazard label; (2) locating the needle-disposal container in the operatory close to where the needle will be used; and (3) avoiding carrying unsheathed contaminated needles or containers in a manner that could endanger others or would allow the needles to be accidentally spilled.

If approved disposal containers are limited in number, the well-closed container should be moved to where it is needed during cleanup. Local regulations for the disposal of the container should be followed.

**Precautions to Avoid Injury Exposure**

Pointed instruments without a hollow lumen have minimal capacity to transmit infected blood into a puncture site. The same principles that apply to needles should be reasonably translated and applied, however, to used burs, wires, and sharp instruments from the operatory. Great care should be used in passing instruments and syringes with unsheathed needles to another individual. Sharp and curved ends should be turned away from the recipient's hand. Two-handed resheathing of needles is not permitted. A needle sheath holder or other safety device or technique should be used for the operator to resheath the needle with only one hand.

Burs should be removed from handpieces when the procedure is finished; if left in the handpiece in a hanger, the bur should be pointed away from the hands and body. Hanging
Overview of Aseptic Techniques

The concept of asepsis is to prevent cross-contamination—all items that are touched with saliva-coated hands must be rendered free of contamination before beginning treatment on the next patient. These contaminated items can be discarded; protected by disposable covers; or removed, cleaned, and sterilized. The clinician should not directly touch what he or she does not want to contaminate. A few simple rules that help avoid wasting costly time and effort between patient appointments are as follows:

During each appointment:

1. Remember, whatever is touched is contaminated.
2. Directly touch only what has to be touched (anticipate your needs).
3. Use one of the following to control contamination:
   a. Clean and sterilize dental instruments.
   b. Protect surfaces and equipment that are not sterilized with disposable, single-use covers (barriers). Discard them after every appointment. Use disposable covers on portable items (e.g., curing-lamp handles, amalgam mixers, and plastic air-water syringe tips).
   c. Use a paper towel, tongs, or plastic bag over gloves to handle equipment briefly or to open cabinets and drawers to get things that were not anticipated during setup.
   d. Scrub and disinfect noncritical surfaces as well as possible. These include any countertops that cannot be covered (and may collect aerosols or spatter) or things that may be accidentally touched, such as room door handles and light switches. With practice, these areas should not become contaminated.

When consistently practiced, these concepts of asepsis can reduce exposure risks, cross-infection risks, and cleaning and disinfecting numerous items in the operatory between appointments. Good asepsis practice also reduces or eliminates the need to clean or disinfect nonoperative areas of the dental office because office personnel avoid contaminating these areas. Examples of items found contaminated in studies of dental offices include telephones, faucet handles, switches, cabinet and drawer handles, radiography controls, lamp handles, door handles, charts, and pens. Evidence of potential cross-contamination and cross-infection risks for patients and personnel related to contact with contaminated surfaces was presented at the beginning of the chapter.

With treatment-soiled gloves, the clinician should avoid unnecessary contact with all switches, drawers, dispensers, or surfaces on the unit that need not be touched. The clinician should use the wrist, arm, or paper towel to operate faucet handles and soap dispenser handles that are not automatic. The clinician should wrap in foil or use a paper towel to handle the phone and drawer pulls. When it is necessary to record findings in a patient’s chart, the clinician should deglove and wash hands. If recording electronically, plastic key covers should be used and routinely disinfected.

Single-use plastic bags should be used on the control unit and chair back, foil or small plastic bags on lamp handles, and adherent plastic sheets or a plastic bag on the radiography cone (Online Fig. 19-9). A thin plastic overglove or a gauze or paper towel should be used to avoid contaminating other objects. Foot controls should be used for faucets, dental chair, and radiography button. In addition, light-curing units and amalgamators should be covered with custom-fitting plastic barriers to avoid contamination. Once a day, or as needed, any water-based tuberculocidal disinfectant licensed by the EPA should be used to clean and disinfect other environmental surfaces in the operatory and laboratory.

Operatory Asepsis
Protection of Operatory Surfaces: Rationale, Materials, and Methods

Operatory surfaces that are repeatedly touched or soiled are best protected with disposable covers (barriers) that can be discarded after each treatment (see Online Fig. 19-9). Changing the covers eliminates cleaning and disinfecting the surface; saves time, effort, and expense; and can be more protective. White paper sheets (“white newsprint”) are useful for workbenches and operatory surfaces on which dry contaminated materials are placed. For dental unit trays, paper, plastic film, or surgical pack wraps (paper or towels) should cover the entire tray, including edges. Clear-plastic bags are available that fit many chair backs, control units, x-ray equipment, suction handles, and air-water syringe handles (see Online Fig. 19-9).

After each appointment, bags and covers can be discarded and replaced without cleaning and disinfecting the covered equipment items. If the covers come off, become torn, or otherwise allow equipment to become contaminated, the item should be thoroughly cleaned and disinfected before re-covering it for the next appointment.
**Preparation of Semi-Critical Items (Attached to the Dental Unit for Reuse) and Noncritical Items (Supporting or Environmental)**

Instruments that come in contact with cut tissues or that penetrate tissues are considered critical items that require thorough cleaning and sterilization for reuse. Many items attached to the dental unit are used intraorally. They are handled by gloved hands coated with blood and saliva or may touch the mucosa. CDC guidelines consider these semi-critical items. Items that are not usually touched during treatments are considered noncritical items.

**SEMI-CRITICAL ITEMS**

Semi-critical items that touch mucosa are the air-water syringe tip, suction tips, prophy angle, and handpieces. Others (air-water syringe handle, suction hose ends, lamp handle, and switches) are handled or touched interchangeably with treatment instruments that become contaminated with blood and saliva. Semi-critical items must be removed for cleaning and sterilization unless they are disposable or can be protected from contamination with disposable plastic covers. This applies especially to air-water syringe tips.

Semi-critical items should not be merely disinfected. As stated before, they should be covered, cleaned, and sterilized, or they should be discarded. Some bacteria often remain even after the use of the best disinfectant. When a cover comes off, or when disinfection is the only recourse, semi-critical items must be scrubbed clean, preferably at the sink, and disinfected. Surface disinfection is inadequate for items with a lumen, such as air-water syringe tips.

**NONCRITICAL ITEMS**

Noncritical items are environmental surfaces such as chairs, benches, floors, walls, and supporting equipment of the dental unit that are not usually touched during treatments. Contaminated noncritical items require cleaning and disinfection.

One should wear protective utility gloves to clean equipment that cannot be covered. For cleaning and disinfecting environmental surfaces, nitrile latex utility gloves are preferable. Disinfectants can penetrate treatment gloves to irritate covered skin, and these less sturdy gloves are prone to small tears. Uncovered chair arms may become contaminated with spatter and should be covered with a protective barrier or disinfected. Areas of the chair not contaminated by spatter need not be disinfected except for housekeeping purposes. Chair backs and control units are covered to protect control buttons from operator gloved finger contamination and spatter and from the damaging effects of disinfectants, and time for disinfecting is reduced.

**DISINFECTANTS**

Preferred disinfectants are those that are approved by the Environmental Protection Agency (EPA). Disinfectants also must be active against the Mycobacterium species and inactivate polioviruses or coxsackieviruses (because they are non-lipid viruses similar to HBV in resistance), common respiratory viruses, and common bacterial hospital pathogens (e.g., Staphylococcus and Pseudomonas species). All such disinfectants readily inactivate HIV in 1 to 2 minutes.

The activity of a disinfectant is reduced by organic debris or blood. Iodines are especially sensitive to the presence of blood. Most water-based disinfectants are effective in removing dried blood. Alcohols tend to harden whole blood that is dried on surfaces, making the surfaces difficult to clean. (Alcohols were used to harden and fix blood films on glass slides in hematology laboratories). Disinfectants containing 70% to 79% ethyl alcohol are considered the most effective disinfectants on cleaned surfaces.

The chlorine and iodine in some disinfectants can react with or be absorbed by the plastic in some types of dispensing bottles, which must be refilled with fresh solution daily. Manufacturer’s directions should be consulted and followed in this regard. Glutaraldehydes at concentrations used for instrument disinfection are too toxic to be used on operatory surfaces and take at least 20 minutes to kill the Mycobacterium species.

Regarding disinfection, two principles should be remembered: (1) Disinfection cannot occur until fresh disinfectant is reapplied to a thoroughly cleaned surface. (2) Disinfection does not sterilize.

Manufacturers specify a time to leave items wet with disinfectant for effective disinfection. Data on kill times should be obtained from the manufacturer. After sufficient time, wet items can be dried with a paper towel.

**Step-by-Step Preparation of the Dental Chair, Dental Unit, and Instruments**

In addition to being unacceptable for semi-critical items, the disinfectants generally considered most active against microorganisms are the most drying or destructive to plastic chair covers and equipment. This fact validates the use of covers, whenever possible. When covers are used, the effectiveness of the disinfectants becomes less critical, and protecting equipment is easier.

Following are step-by-step standard operating procedures for the preparation of the dental chair, dental unit, and instruments between appointments. (As mentioned earlier, it is unnecessary to disinfect surfaces and items covered with plastic drape after each treatment, unless the plastic cover was torn or came off during treatment.)

1. With gloved hands after the last treatment, remove and invert the chair back cover, discard cotton rolls and other disposable materials into the cover, and discard the cover into the operatory trash bin. Remove and discard gloves aseptically.
2. Wash hands with antiseptic hand soap, rinse, and dry or use an accepted alcohol hand rub.
3. Place three paper towels on the seat of the dental chair for later placement of air-water syringe and ends of suction hoses. Don nitrile latex utility gloves.
4. With the used suction tip, clean saliva and debris from the cuspidor trap, if present. Discard the disposable suction tip into the operatory trash bin.
5. Remove (unscrew) the resheathed needle from the anesthetic syringe, and discard it with all other sharp disposable items in a sharps container. Using a Stickshield is advised. Remove the anesthetic cartridge before removing the needle to decrease the risk of an occupational needlestick injury. Handling needles without using a protective one-handed capping device and gathering instruments without heavy protective gloves account for most injury exposure incidents.
6. Place any loose sharp instruments and instrument cassettes into a perforated metal basket, and then lower the basket into the disinfectant solution in a covered hard-walled pan. Return the handpieces and the pan of instruments to the cleanup area. Using the handles provided, remove the basket of instruments, rinse, and place into the ultrasonic cleaner.

7. Before handling disinfectant-dispensing bottles, wash the utility gloves (on hands) with antiseptic scrub, rinse, and dry.

8. Spray any used bottles, containers, and tubes with disinfectant, and wipe with a paper towel. Spray again, and leave the items damp with disinfectant as they are put away. Spraying in this manner has been found to be effective.9,10 Disinfectant wipes that are available in the marketplace can be used, if any concern exists about breathing in irritating or possibly harmful aerosols from spray disinfectants.

9. Remove the air-water syringe (now minus its removable tip) and suction hoses from the hangers on the control unit. Remove the plastic covers from the hose ends and discard. Lay the air-water syringe and suction hose ends on the paper towels previously placed on the dental chair.

10. Invert, remove, and discard the plastic drapes from the control unit (Online Fig. 19-10); remove and discard the protective covers from lamp handles and the surface covering from the side table. These disposables may be placed into the large bag and removed from the control unit.

11. For any controls and switches that were not covered, use a disinfectant wipe to wipe the lamp switch and controls that were contaminated. Do not spray control switches. Wipe any contaminated surfaces not previously covered, including the side table, arms of dental chair, contaminated drawer handles, radiographic viewbox switch, and paper towel dispenser. Discard the used disinfectant wipe.

12. Using a second disinfectant wipe, rewet these items, and leave them wet.

13. Spray the outside and inside of the cuspidor, if present, with disinfectant. Use two paper towels to prevent your gloves from contacting the cuspidor while first wiping the outside and then the inside of the cuspidor. Discard the towels. Wipe any overspray of disinfectant from the operatory floor. Discard the towels in the trash bin. Disinfectant wipes could also be used.

14. Spray any contaminated faucet handles, sink countertops, and trash disposal openings with disinfectant, and wipe dry with paper towel. Discard the towel, and re-spray the areas with disinfectant and leave them damp. Disinfectant wipes could also be used.

15. Wash the utility gloves (still on hands) with a strong antiseptic hand scrub or disinfectant cleaner, rinse thoroughly, and dry them with paper towels. Discard the towels into the trash bin. Remove the utility gloves, and re-hang them in the operatory. Wash hands. Contaminated utility gloves can be cleaned and disinfected. Nitrile latex gloves can be autoclaved.

To prepare the unit for the next patient, gloves need not be worn if only the clean surfaces that have been protected with covers are touched. The unit is prepared as follows:

1. Pull a large clear plastic bag cover over the dental control unit from the front, and tuck the excess up under the unit (see Online Fig. 19-9).

2. Pull another bag down over the chair back; also cover the chair arms.

3. Install the suction and air-water syringe tips. Place a slender bag over each tip, pushing the tip through the end of the bag, then sliding the bag down to cover all of the handle. For the suction tip, wrap autoclave tape at the tip–bag junction to secure the bag against creeping and to prevent contamination of the handle area of the hose (Online Fig. 19-11). It is usually unnecessary to tape the bag onto the air-water syringe. Press the handles into the forked hangers on the unit that are covered by the plastic bag (Online Fig. 19-12).

4. Install the sterilized handpieces. A plastic sleeve may be used to cover the motor-end of the low-speed handpiece that is not sterilized (see Online Fig. 19-9). Re-hang the handpieces. If the plastic film obstructs the electric eye in the hanger, use a small finger to pull out the film when the handle is removed.

5. Set out the materials and instrument packs; open the packs, being careful not to touch the sterilized instruments with bare hands.

6. Seat the patient, and put on a clean mask, eyewear, and gloves.

**Protection of Complex Devices Against Contamination**

Cameras, light-curing units, lasers, intraoral cameras, computers, and air abrasion units are examples of complex devices that must be protected against contamination. They are used in the operatory and cannot be sterilized or readily disinfected. Clear plastic bags of suitable size obtained from plastics or dental supply companies are effective single-use protective barriers.
Install the suction tip and cover it with a slender plastic bag. Push the tip through the end of the bag, and continue sliding the bag to cover the handle area of the hose. Wrap a piece of suitable tape at the bag–tip junction, as shown, to secure the bag against creeping and prevent exposing the handle to contamination. After use, the bag comes off with the plastic tip for easy removal and disposal.

Replace equipment attached to hoses by using the device to press the loose plastic film into the forked holder.

Procedures, Materials, and Devices for Cleaning Instruments Before Sterilization

According to ADA guidelines and CDC specifications, instruments that touch mucosa or penetrate tissues must be cleaned and sterilized before reuse (Online Box 19-1).11,46

Principles and Procedures for Handling and Cleaning Instruments after Treatment

Instrument cleaning procedures should be designed to be effective, while avoiding risks such as grasping and scrubbing groups of single-ended and double-ended sharp instruments. Instrument grasping and scrubbing are the most exposure-prone tasks encountered after treatments, even when protective utility gloves are worn. Protective utility gloves made of nitrile latex are the most puncture resistant and are obtainable from dental suppliers. These gloves can be washed and wiped with disinfectant or autoclaved after use, as needed. Household utility gloves are not suitable for handling and cleaning sharp instruments. The safest and most efficient instrument cleaning procedures involve ultrasonic cleaning of used instruments kept in a perforated basket or cassette throughout the cleaning procedure.22,43,105,106 Protective utility gloves should be worn at all times to safely handle contaminated containers and instruments.

Procedures for Instrument Processing

Instrument cassettes and any loose instruments should be transported to the cleanup area in a perforated metal or plastic basket that can be lowered by its handles into a disinfectant detergent solution contained in a covered hard-walled pan. Organic debris on instruments is likely to reduce the activity of the disinfectant. Soaking used instruments before cleaning and loosening any dried debris. Instruments should be left in the basket or cassette while rinsing them well. Next, the instruments in the cassette or basket are moved into an ultrasonic device.

<table>
<thead>
<tr>
<th>Online Box 19-1 Do’s and Don’ts of Instrument Recycling</th>
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<tbody>
<tr>
<td><strong>Do:</strong></td>
</tr>
<tr>
<td>▪ Wear protective puncture-resistant gloves to handle used instruments.</td>
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<tr>
<td>▪ Keep instruments wet in an antibacterial solution before cleaning.</td>
</tr>
<tr>
<td>▪ Use an ultrasonic cleaning device.</td>
</tr>
<tr>
<td>▪ Test and maintain the ultrasonic device periodically.</td>
</tr>
<tr>
<td>▪ Use good-quality sterilizer equipment.</td>
</tr>
<tr>
<td>▪ Read the operator’s manual, and follow operation instructions for the sterilizer.</td>
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<tr>
<td>▪ Have sterilizers annually inspected regarding gaskets, timer, valves, and temperature and pressure gauges.</td>
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<tr>
<td>▪ Use proper water or chemicals to operate, clean, and maintain sterilizer.</td>
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<tr>
<td>▪ Place only dry instruments in the sterilizer.</td>
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<tr>
<td>▪ Use a wrap that will be penetrated by the steam or gas used.</td>
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<tr>
<td>▪ Load the sterilizer loosely; leave air space between large packs.</td>
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<tr>
<td>▪ Read the sterilizer temperature and pressure gauges daily.</td>
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<tr>
<td>▪ Use the complete sterilizer monitoring system outlined; use indicators daily and spore tests weekly.</td>
</tr>
<tr>
<td>▪ Keep a record of daily indicators and spore tests.</td>
</tr>
<tr>
<td><strong>Don’t:</strong></td>
</tr>
<tr>
<td>▪ Place wet instruments into any type of sterilizer unless so instructed.</td>
</tr>
<tr>
<td>▪ Overwrap cloth packs or use impermeable wraps for steam or chemical vapor pressure sterilization.</td>
</tr>
<tr>
<td>▪ Use closed, nonperforated trays, foil, canisters, or other sealed containers in gas or steam sterilizers.</td>
</tr>
<tr>
<td>▪ Overload or cram packs together in the sterilizer.</td>
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<tr>
<td>▪ Decrease the required time for sterilization.</td>
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<tr>
<td>▪ Add instruments to a sterilizer without restarting the cycle.</td>
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<tr>
<td>▪ Sterilize viability control strips supplied with spore tests.</td>
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</tbody>
</table>
container is covered to transport the instruments to the cleanup area.

2. Reusable contaminated sharps should not be stored or processed in a manner that requires employees (with or without protective gloves) to reach into containers where these sharps have been placed.34,45

When it is necessary to clean the instruments by hand, a suitable brush and a disinfecting cleaner should be used. Severe irritation, infection of unprotected eyes, or both can result from spatter of the disinfectant, detergents, or chlorhexidine gluconate hand cleansers often used to scrub instruments. As mentioned before, hand injury from double-ended instruments is the other main risk.

Heavy gloves, eye protection, a mask or a face shield, and a protective garment or apron should be worn as protection against spatter. A long-handled pan-scrubbing brush should be used. The mid-handle portion of only a few instruments should be grasped at a time with fingers and thumb to protect the palm and to rotate the instruments. One should brush away from the self, down into the sink, using at least five strokes per end while rotating them. Attention should be paid to removing visible soil and debris. Rinsing is done with an aerated stream of water to avoid spatter. To remove coatings such as plaster, wax, cement, and impression material, they should be scraped or an appropriate solvent cleaner used. When the cleaning is finished, heavy gloves, disinfectant, and paper towels should be used to clean up the spattered or contaminated surfaces around the sink.

**Ultrasonic Cleaners and Solutions**

Ultrasonic cleaning is the safest and most efficient way to clean sharp instruments (see Online Fig. 19-13). Burs should be ultrasonically cleaned as well. To contain burs, they can be placed in a fine screen basket, metal tea ball, or bur caddy. Some hinged instruments (e.g., some brands of orthodontics pliers) should not be submerged in ultrasonic or disinfectant cleaning solutions if hinges would corrode or rust. The manufacturer’s directions should be followed in this regard.

Ultrasonic cleaning can be nine times more effective than hand cleaning if the ultrasonic device functions properly and is used as directed by the manufacturer.106 An ultrasonic cleaning device should provide fast and thorough cleaning without damage to instruments; have a lid, well-designed basket, and audible timer; and be engineered to prevent electronic interference with other electronic equipment and office communication systems. Procedures for ultrasonic cleaning are as follows:

1. Observe operating precautions.
2. Operate the tank at one half to three fourths full of cleaning solution at all times. Use only cleaning solutions recommended by the manufacturer of the ultrasonic device. Change solutions, as directed. An antimicrobial cleaning solution is preferable.
3. Operate the ultrasonic cleaner for 5 minutes or longer, as directed by the manufacturer, to achieve optimal cleaning, possibly 1 minute per instrument.
4. Remove coatings such as plaster, wax, cement, and impression material with an appropriate solvent cleaner, and place the instrument(s) and/or impression
Instrument Containment

Cloth packs, wraps, tubes of nylon film, and commercial paper or plastic bags are suitable for instrument containment if they are compatible with the method and temperature of sterilization. Various kinds of instrument trays and cassettes (Online Fig. 19-14) are manufactured to contain the instruments at chairside, and they can be placed in an ultrasonic cleaner, rinsed, and packaged ready for sterilization. Cassettes provide convenience, safety in handling and cleaning batches of instruments, and maintenance of instrument organization for efficient use.

Sterilization

Dental patients with infections often go undetected. Sterilization provides a method of instrument recycling that can be monitored and documented to show that conditions for control of disease transmission were established. Because most instruments contact mucosa or penetrate oral tissues, it is essential that contaminated reusable instruments be cleaned and sterilized thoroughly by using accepted methods that can be tested and monitored routinely. Heat sterilization takes less time compared with high-level sporicidal disinfection, which is required when heat or gas sterilization cannot be used. Sterilization practices were found unreliable in 15% to 31% of dental offices surveyed where routine monitoring was not used to evaluate and maintain correct sterilization performance.
The four accepted methods of sterilization are as follows:

1. Steam pressure sterilization (autoclave)
2. Chemical vapor pressure sterilization (chemiclave)
3. Dry heat sterilization (dryclave)
4. Ethylene oxide (ETOX) sterilization

Each method and each commercial modification has specific requirements with regard to timing, temperature, suitable packaging of materials, and kinds of items and materials that can be sterilized safely and effectively.11,46 Ignoring any of these specifications can prevent sterilization or damage materials or instruments.

It is best to evaluate the office needs, examine various sterilizer capabilities, and then carefully select one or two methods of sterilization. Kinds and sizes of sterilization equipment depend on the treatment instrumentation used in the practice. Stainless steel instruments and mirrors used for operative, endodontic, periodontic, or dental hygiene procedures can be sterilized by any accepted method. High-speed and low-speed handpieces are best autoclaved. Burs (discussed later) can be sterilized safely by dry heat or chemical vapor in a chemiclave or in a gas sterilizer, but they may rust or corrode if not protected from steam in the autoclave. Metal impression trays can be sterilized by any method, but dry heat greater than 345°F (174°C) may remove the soldered handles. Orthodontic pliers of high-quality stainless steel resist corrosion in an autoclave; lower-quality stainless steel found in some pliers must be sterilized by dry heat or chemical vapor. Towels and towel packs of instruments needed for surgery are best sterilized by autoclaving; chemical vapor pressure sterilization does not penetrate cloth effectively. The widest variety of instruments probably would be found in pediatric dentistry, and more than one sterilization method may be required.

A sterilizer is used every day of practice. Therefore, reliable sterilization equipment of proper size and cycle compatible with needs of the practice should be chosen. Patient load, turnaround time for instrument reuse, size of instrument inventory, instrument variety, and instrument quality all must be balanced against the type and size of sterilizer selected.

Steam Pressure Sterilization (Autoclaving)
Sterilization with steam under pressure is performed in a steam autoclave (Online Fig. 19-15). For a light load of instruments, the time required at 250°F (121°C) is a minimum of 15 minutes at 15 lb of pressure. Time for wrapped instruments can be reduced to 7 minutes if the temperature is increased to approximately 273°F (134°C) to give 30 lb of pressure. Time required for the sterilizer to reach the correct temperature is not included. Bench models may be automatic or manually operated. Manual sterilizers should have a temperature and pressure gauge so that temperatures can be related to corresponding pressure required for sterilization. In contrast to hospital autoclaves, bench models depend on gravity flow to distribute steam throughout the load, rather than first evacuating air from the sterilizer and refilling it with steam. Bench models require more caution against the use of large or tightly packed loads. Steam must enter and circulate around packs easily. Instrument pans or other impermeable instrument containers must be left open so that steam can enter. Except for containers of solutions, all metal items must be dry. Moisture evaporating from instruments can slow the heating process. Sterilization must be tested routinely (see section on monitors of sterilization).11,46

Advantages of Autoclaving
Autoclaving is the most rapid and effective method for sterilizing cloth surgical packs and towel packs. Other methods are not suitable for processing cloth packs. Automated models are available, although they can be misused; they must be evaluated with a biologic spore test monitoring system.

Disadvantages of Autoclaving
Items sensitive to the elevated temperature cannot be autoclaved. Autoclaving tends to rust carbon steel instruments and burs. Steam seems to corrode the steel neck and shank portions of some diamond instruments and carbide burs.

Autoclave Sterilization of Burs
For autoclave sterilization, burs can be protected by keeping them submerged in a small amount of 2% sodium nitrite solution.19,43 Sodium nitrite crystals (not nitrate) can be obtained from distributors of scientific products and chemicals or a pharmacy. Nitrite 20 g (2/3 oz) is added to 1 L of pure...
water and stored tightly sealed. After ultrasonic cleaning, burs can be rinsed and placed into any small metal or glass beaker with a perforated lid (e.g., a metal salt shaker). The beaker should be filled with sufficient fresh nitrite solution, with the level of the solution approximately 1 cm above the burs. The container is left uncovered, or a perforated cover is used. The container of burs and fluid is placed into the sterilizer, and a normal sterilization cycle is operated. The fluid from the container is discarded through the perforated lid. Sterile forceps should be used to place the burs into a sterilized bur holder or tray. The burs are stored dry. Before use, any nitrite residue can be wiped away or rinsed off with clean or sterile water, if desired.

Chemical Vapor Pressure Sterilization (Chemiclaving)
Sterilization by chemical vapor under pressure is performed in a chemiclave (MDT Biologic Co, Rancho Dominguez, CA). Chemical vapor pressure sterilizers operate at 270°F (131°C) and 20 lb of pressure. They are similar to steam sterilizers and have a cycle time of approximately 30 minutes. Similar to ETOX sterilizers, they must be used with a prescribed chemical and should be labeled properly to satisfy OSHA’s Chemical Hazard Communication Standard. Newer models seem to handle aldehyde vapors well; vapors from older models must be safely vented. Loading cautions similar to those for autoclaving must be used. Water left on instruments loaded into the chamber can prevent sterilization.

Advantages of Chemiclaving
Carbon steel and other corrosion-sensitive burs, instruments, and pliers are said to be sterilized without rust or corrosion.

Disadvantages of Chemiclaving
Items sensitive to the elevated temperature are damaged. Instruments must be lightly packaged in bags obtained from the sterilizer manufacturer. Towels and heavy cloth wrappings of surgical instruments may not be penetrated to provide sterilization. Biologic spore test monitoring strips need to be used routinely to confirm heat penetration of heavy packs before using them (see the section on monitors of sterilization). Only fluid purchased from the sterilizer manufacturer can be used. Only dry instruments should be loaded, and the door gasket should be checked for leaks to avoid frequent sterilization monitoring failures.

Dry Heat Sterilization
Conventional Dry Heat Ovens
Dry heat sterilization is readily achieved at temperatures greater than 320°F (160°C). Conventional professional dry heat ovens that have been sold for instrument sterilization have heated chambers that allow air to circulate by gravity flow (gravity convection). Packs of instruments must be placed at least 1 cm apart to allow heated air to circulate. Individual instruments must be heated at 320°F (160°C) for 30 minutes to achieve sterilization. Increasing the total time by 50% as a safety factor is recommended. Total time required also depends on the efficiency of the oven based on its size, the size of the load, and how instruments are packaged. Foil wrap or special nylon bags are used. Approximately 60 to 90 minutes may be required to sterilize a medium load of lightly wrapped instruments in an oven set at a range of 335°F (168°C) to 345°F (174°C). Temperatures vary at least 5 degrees above and below the setting, so a range rather than a specific temperature must be set. Use of a sterilizer not reviewed by the FDA for instrument sterilization or using one inappropriately may result in the dentist being liable for any adverse consequences.

Without careful calibration, more sterilization failures are obtained with gravity convection dry heat ovens than any other type of sterilizer. The only accurate way to calibrate a sterilization cycle in most relatively inexpensive industrial and professional dry heat ovens is by using an external temperature gauge (pyrometer) attached to a thermocouple wire. The other end of the wire is extended inside the oven and tied to an instrument in a centrally located pack to measure its exact temperature. Battery-operated pyrometers are available from scientific supply companies.

Short-Cycle, High-Temperature Dry Heat Ovens
A rapid high-temperature process that uses a forced-draft sterilization chamber (a mechanical convection sterilization chamber that circulates heated air with a fan or blower) is available. It reduces total sterilization time to 6 minutes for unwrapped instruments and 12 minutes for wrapped instruments. These short-cycle, high-temperature dry heat sterilizers operate at 375°F (190°C). The chamber size of one brand is limited to processing about one set of instruments at a time but is more effective for wrapped instruments and may be adapted for a shorter heat disinfection cycle (consult the manufacturer).

Before purchasing a rapid dry heat sterilizer, care must be taken to verify that the sterilizer manufacturer has undergone premarket review by the FDA for its instrument sterilization device. This requirement has been ignored by some clinicians.
who have adapted nonprofessional equipment for office use. Legal professionals have begun to anticipate how a jury may view the use of home ovens to sterilize professional treatment instruments. Moderately priced small ovens manufactured for industrial and scientific use by industrial manufacturers (e.g., Blue M Electric Co, Blue Island, IL) are usually more accurate and reliable than ovens designed for home use. Careful calibration with a pyrometer to ensure that instruments reach and maintain sterilization temperatures is imperative. Evidence of FDA review of the equipment for instrument sterilization or legal advice before purchasing and using this type of oven for instrument sterilization should be obtained. Proper, weekly monitoring of all sterilizers, including dry heat ovens, is imperative. Some sterilization monitoring services now refuse to monitor sterilizers that have not undergone premarket review by the FDA.

**Advantages of Dry Heat Sterilization**

Carbon steel instruments and burs do not rust, corrode, or lose their temper or cutting edges if they are well dried before processing. Industrial forced-draft hot air ovens usually provide a larger capacity at a reasonable price. Rapid cycles are possible at high temperatures.

**Disadvantages of Dry Heat Sterilization**

High temperatures may damage more heat-sensitive items such as rubber or plastic goods. Sterilization cycles are prolonged at lower temperatures. Heavy loads of instruments, crowding of packs, and heavy wrapping easily prevent sterilization. Cycles are not automatically timed on some models. Inaccurate calibration, lack of attention to proper settings, and adding instruments without restarting the timing are other common sources of error.

**Ethylene Oxide Sterilization**

ETOX sterilization is the best method for sterilizing complex instruments and delicate materials. The clinician must verify, however, that the sterilizer intended for use has had a premarket review by the FDA for sterilizing handpieces. Automatic devices sterilize items in several hours and operate at elevated temperatures well below 100°C. Less expensive devices operate overnight to produce sterilization at room temperature (Online Fig. 19-17). Both types meet OSHA requirements. Porous and plastic materials absorb gas and require aeration for 24 hours or more before it is safe for them to contact skin or tissues. Units with large chamber sizes hold more instruments or packs per cycle; however, they are expensive. Some chamber designs or sizes are better suited to accept stacks of instrument trays. Manufacturers should be consulted to obtain detailed information about these sterilizers. Consult infection control texts or dental product distributors.

**Boiling Water**

Boiling instruments in water does not kill spores and cannot sterilize instruments. Heat can reach and kill blood-borne pathogens, however, in places that liquid sterilants and disinfectants used at room temperature cannot reach. Boiling is a method of high-level disinfection that has been used when actual sterilization cannot be achieved (e.g., in case of a sterilizer breakdown). Well-cleaned items must be completely submerged and allowed to boil at 98°C to 100°C (at sea level) for 10 minutes. Great care must be exercised to ensure that instruments remain covered with boiling water the entire time. Simple steaming is unreliable. Pressure cooking, similar to steam autoclaving, is preferable and would be required at high altitudes.

**New Methods of Sterilization**

Various new methods of sterilization are under investigation and development. The microwave oven has major limitations for sterilizing metal items, including damage of the machine caused by the metal and the inability to reach all sides of the instruments. Research efforts to overcome such limitations are ongoing. UV light is not highly effective against RNA viruses such as HIV and is not effective against bacterial spores.50,110 Incomplete exposures of all surfaces and poor penetration of oil and debris are other limitations. UV irradiation may be useful for sanitizing room air to help control tuberculosis bacteria.10 One valuable guide to whether a commercial device is an effective sterilizer is determining whether the FDA would find it equivalent to other effective and proven devices now in common use. Before purchasing any medical device in question, the clinician should require the manufacturer to provide documentation of FDA premarket review.
become a standard of care. Monitoring services are provided by most major schools.

In the microbiology literature, sterilization is defined as killing all forms of life, including the most heat-resistant forms, that is, bacterial spores. For instruments that can penetrate tissues, sterilization provides control of spore-forming tetanus and gas gangrene species and all pathogens borne by blood and secretions. For instrumentation used in body cavities that routinely touch the mucosa, sterilization provides a margin of safety for ensuring destruction of HBV, mycobacteria, and other pathogenic bacteria and viruses that can be involved in cross-infections.

Weekly sterilization monitoring of highly efficient automated sterilizers in hospitals has been mandated for many years by the Joint Commission of Accreditation of Hospitals (Chicago, IL), an organization formed by the profession to monitor and accredit its own performance. Many state examining or disciplinary boards now have provided that type of regulation. In dental offices, sterilization must be monitored weekly with biologic spore tests using heat-resistant spores and color-change, process-indicator strips in each pack (internal and external).1,11,46 Documentation of routine monitoring in a daily-entry sterilization log makes it possible to confirm the efficient performance of the sterilizer operator and proper functioning of the equipment. Problems thus can be identified and corrected. Evidence of effective sterilization also is available when unavoidable localized or systemic post-treatment infections occur and instrument sterilization may be questioned. Sterilization monitoring has five components: (1) mechanical monitoring, (2) chemical indicator strip in each pack, (3) external sterilization indicator on the outside of each pack, (4) weekly biologic spore test, and (5) documentation log.

**Mechanical Monitoring**

Each sterilized load must be mechanically monitored to document time, temperature, and pressure. Many sterilizers have a printout tape that does this automatically. Otherwise, the clinician manually observes the maximum temperature and pressure and documents the data in a log.

**Chemical Indicator Strips**

Chemical indicator strips provide an inexpensive, qualitative monitor of sterilizer function, operation, and heat penetration into packs. The clinician places one of the inexpensive color-change indicator strips into every pack. Chemicals on the strip change color slowly, relative to the temperature reached in the pack. As soon as the pack is opened, the strip can immediately identify breakdowns and gross overloading. The strip is, however, not an accurate measure of sterilization time and temperature exposure.

**External Sterilization Indicators**

External sterilization indicators, including tapes and bags, are marked with heat-sensitive dyes that change color easily on exposure to heat, pressure, or sterilization chemicals. Such heat-sensitive markers are important to identify and distinguish the packs that have been in the sterilizer from those that have not. Used alone, these indicators are not an adequate measure of sterilization conditions. Sterilization is task dependent as much as time and temperature dependent. Packs should always be dated and rotated.

**Biologic Monitoring Strips**

A biologic monitoring spore test strip is the accepted weekly monitor of adequate time and temperature exposure. Spores dried on absorbent paper strips are calibrated to be killed when sterilization conditions are reached and maintained for the time necessary to kill all pathogenic microorganisms. Additionally, any pack containing an implantable device must be biologically monitored. An assistant processes a spore strip in a pack of instruments in an office sterilizer each week. Tests can be evaluated in the office. By sending the strip to a reference laboratory for testing, however, the dentist obtains independent documentation of monitoring frequency and sterilization effectiveness. In the event of failure, such laboratory personnel provide immediate expert consultation to help resolve the problem.

**Documentation Log**

In a log, a single, dated, initialed indicator strip is attached to a sheet or calendar for each workday, followed by a weekly spore strip report. The log provides valuable sterilization documentation. Dated sterilized instrument packs, bags, and trays provide the final evidence of the sterilization program.

**Liquid Sterilants and High-Level Disinfectants**

Liquid sterilants can kill bacterial spores in 6 to 10 hours. These sterilants are high-level disinfectants and are EPA registered. Sterilants used for high-level disinfection of items for reuse are glutaraldehydes at 2% to 3% concentrations. Repeated use greater dilutions are not advisable.

Organic matter and oxidation reduce the activity of reused disinfectant baths. Placing wet items into disinfectant trays dilutes the solution. Despite reuse claims of several weeks’ duration, studies have shown that disinfectants in heavy use often lose activity during the second week.111 Glutaraldehydes are irritating, are sensitizing to skin and respiratory passages, and can be toxic as indicated in manufacturers’ safety data sheets.78 Trays should be kept tightly covered in a well-ventilated area. Use of 2% or greater glutaraldehyde solutions to wipe counters or equipment (e.g., dental unit and chair) should be avoided. Most glutaraldehydes require 20 minutes to kill tuberculosis bacteria, in contrast to some synthetic phenol complexes and alcohols, which act in 10 minutes or less and are much less toxic.

**Uses of High-Level Disinfection**

According to the CDC, instruments that penetrate tissues or contact mucosa are termed critical or semi-critical and require cleaning and heat or gas sterilization before reuse.5,13,78 Few, if any, instruments now exist that cannot be heat sterilized. High-level disinfection is used mainly for plastic items that enter the mouth and that cannot withstand heat sterilization. Plastic cheek retractors, photographic mirrors, and similar heat-sensitive devices should be replaced with metal types that
can be heat sterilized. Disinfection for 20 to 90 minutes in glutaraldehyde germicides is inappropriate for instruments used in the mouth. Most require 6 or more hours for sterilization. Liquid sterilants cannot process pre-packaged instruments or be completely monitored with biologic indicators. Prophy cups should be discarded and never disinfected for reuse. Used anesthesia carpules and anesthesia needles must be discarded after a patient appointment and never be disinfected or heat sterilized for reuse.

Types of Instruments and Sterilization Methods

Periodontal, restorative, and endodontic instruments are readily processed by autoclave or chemical vapor pressure sterilization. Carbon steel instruments and burs, if dried well before sterilizing, are best sterilized by dry heat and chemical vapor pressure sterilizers because these methods reduce the risk of rust.

Dental Control Unit Water Systems and Handpiece Asepsis

The high-speed handpiece is one component of a complex system of instrumentation operated by the dental operator master control unit. Within the head of the handpiece and supported by delicate bearings, a turbine assembly holds and rotates the cutting instrument at the speeds preferred for tooth preparation. The handpiece is attached by flexible plastic lines to the dental unit that controls air and water supplied to the handpiece. A small orifice located below the neck of the handpiece near the bur supplies either a jet of air to blow away cutting debris or an air-water spray emitted from the same orifice to lubricate and clean the cutting site; this spray also cools the cutting bur.

These components constitute a complex system that is vulnerable to several unique kinds of contamination by and through the handpiece. Oral fluid contamination problems of rotary equipment, especially the high-speed handpiece, involve (1) contamination of handpiece external surfaces and crevices, (2) turbine chamber contamination that enters the mouth, (3) water spray retraction and aspiration of oral fluids into the water lines of older dental units, (4) growth of environmental aquatic bacteria in water lines, and (5) exposure of personnel to spatter and aerosols generated by intraoral use of rotary equipment.9,43,57,112,113

If not controlled, external and internal contamination of this equipment by oral fluids holds infection potentials for dental patients. Even sterilization of handpieces cannot control contamination related to water spray retraction and bacterial colonization of water lines that holds infection potentials for immunocompromised patients.

Handpiece Surface Contamination Control

Blood and saliva contaminate the surfaces of handpieces during various dental treatments. Irregular surfaces and especially crevices around the bur chuck are difficult to clean and disinfect, especially by briefly wiping with a disinfectant-soaked sponge. Submersion of a high-speed handpiece in a high-level disinfectant has not been an option accepted by manufacturers. In tests, thorough scrubbing and applying the best disinfectants to inoculated smooth handpiece surfaces reduced numbers of simple test bacteria but did not completely eliminate them.104 Only sterilization can accomplish complete infection control of handpiece surfaces.

Turbine Contamination Control

Contaminated oral fluids may be drawn back into the turbine chamber by negative pressure created by a Venturi effect during operation or when the turbine continues to spin whenever the drive air is stopped. Oral fluids also may enter around worn bearing seals or be aspirated into the vent holes in the top of older hand-chuck–operated handpieces or possibly into the air-water spray orifice that communicates with the turbine chamber in some handpieces. The question is whether debris that contains viable microbes in the turbine chamber may be vented from holes in the top of the turbine chamber during the next treatment, as indicated by some investigators.11,59,114

Although turbine contamination can be shown experimentally under extreme conditions on a laboratory bench, it is not clear under what conditions this may occur during clinical treatments, and air-driven high-speed handpieces have not been clearly implicated in this manner of cross-infection. Cross-contamination potentials of water-driven handpieces that have been used in a hospital have been shown more easily.20

Water Retraction System Correction

Dental unit water control systems made before the mid-to-late 1980s used water lines that easily expanded when air-water spray was used and gradually contracted when water pressure was relieved. Handpieces had an annoying tendency to continue to drip immediately after use. To overcome the problem in those units, a device was installed that retracted water in the line whenever the spray was stopped. However, more than just water could be retracted. After use, oral bacteria have been readily recovered from water samples obtained from the handpieces and water lines of those older dental units.9,115

Agencies recommend correcting water retraction by placing a one-way check valve in the water line.5,48,109 Check valves, however, clog and fail. Systems should be tested monthly, if not weekly, to verify lack of water retraction.113 A simple, inexpensive water retraction testing device is available from major dental supply companies that takes only approximately 1 minute.59 The industry also has responded to correct the retraction problem. Since 1988, nearly all manufacturers have produced dental control units that simply cut off the water spray without retraction. The best solution for older dental control units is to replace them with newer units that do not retract unless the older units can be overhauled.11,59,113

Inherent Water System Contamination

Microbes exist in the dental unit water line as free-floating bacteria and as a sessile form known as biofilm. The microorganisms in the biofilm produce a protective polysaccharide matrix that provides them a mechanism for surface attachment and retention to the water line.116,117 This matrix, which can be 30 to 50 mm thick, affords the biofilm flora resistance to antimicrobial agents on the order of 1500 times greater than
normal free-floating bacteria. Because of this resistance to antimicrobial agents, when the biofilm is established, it is difficult to remove.

Bacterial growth in biofilms on the inner walls of dental unit water lines (Online Fig. 19-18) is a universal occurrence unless steps are taken to control it.\(^{116}\) Counts of bacteria that are shed from the biofilms into water of the dental unit may range from thousands to hundreds of thousands of bacteria per milliliter.\(^{112,118-120}\) This bioload could be compared with bacterial counts of some foods (e.g., juices, milk, yogurt) except that the bacterial types present are not carefully controlled. The main inhabitants are opportunistic, gram-negative, aquaphilic bacteria. Similar species are found in biofilms that form in swimming pools or wherever nonsterile water remains in prolonged contact with habitable surfaces. The bacteria may include atypical mycobacteria, pseudomonas, and possibly Legionella bacteria, which can present an infection risk to immunocompromised individuals.\(^{1,111,121,122}\)

Flushing or sterilizing high-speed handpieces cannot be expected to overcome this potential source of contamination of patients and personnel that extends throughout the dental unit water system.

The threat of biofilm in dental unit water lines to public health has not been established. As the characteristics of the population change, however, the link between biofilm bacteria and infection may be verified. The CDC has recommended that dental unit treatment water contain less than 500 colony-forming units (cfu) per milliliter.\(^{1}\) Suggested mechanisms to accomplish this goal of 500 cfu/mL include use of microbial point-of-use filters and independent water systems. The uses of biocide solutions to treat the water lines overnight and as a continuous addition to the treatment water also have been investigated.\(^{117,123,124}\)

Although much work currently is being done in the area of biofilm and dental unit water line contamination, care has to be exercised in selecting the system to control the biofilm. Clean water reservoir systems combined with disinfection or sterilization of equipment downstream have been developed by several companies (Online Fig. 19-19).\(^{62,119}\)

Disinfectants such as an iodophore or diluted sodium hypochlorite that are used to clean the system must be flushed out with clean, boiled, or sterile water before using the system. The handpiece always must be removed before disinfecting the system because 0.5% sodium hypochlorite solution and other strong chemicals would damage the high-speed handpiece and other metal products. Highly diluted biocides that are used continuously in the treatment water must be researched thoroughly because some of them can decrease composite bond strengths to enamel and dentin.\(^{89,123}\) As stated earlier, when biofilm is generated, it can be difficult to remove. Educating dental personnel and periodically monitoring compliance with procedures is paramount for success in preventing dental unit water line contamination.\(^{116}\)

### Control of Contamination from Spatter and Aerosol

Valid concerns exist regarding contamination from spatter and aerosol created by rotary equipment. Operating this equipment in the mouths of patients spatters oral fluids and microorganisms onto the attending clinical personnel, and aerosols can be inhaled. Aerosolization of mycobacteria that cause pulmonary tuberculosis (\textit{M. tuberculosis}) always has been a concern, although an infectious patient coughing in the waiting room or operatory is much more likely to infect others.\(^{10}\) The rubber dam and high-volume evacuation are important and helpful methods for reducing exposure to contamination.\(^{42,44}\) High-volume evacuation can be 80% effective in reducing aerosol contamination. Complete elimination of airborne contamination, however, is impossible unless some method of continuous air purification can be used. Without the universal use of personal barriers, drapes, or effective cleanup procedures, personnel and patients can be subjected to oral fluid–borne contamination.

### Sterilization of Handpieces and Related Rotary Equipments

Prophy angles, latch angles, burs, and rotary stones used in the mouth must be cleaned and sterilized for reuse. All such items are readily sterilized by three or more methods of sterilization. Carbon steel burs require special protection in the autoclave (see the section on sterilization of burs by autoclaving). Handpieces are semi-critical instruments that require
sterilization. Few brands now exist on the market that cannot be routinely autoclaved. Sterilization of handpieces must be monitored and documented. The motor end of the attached low-speed handpiece can be covered by pulling a disposable, single-use, slender plastic bag up over it and pushing (popping) the handpiece through the sealed end of the bag so that the bag covers the motor end and part of the hose (see Online Fig. 19-11). If the handpiece cannot be sterilized, the motor-end is scrubbed and disinfected for each reuse.

**Steam Sterilization of Handpieces**

Autoclave sterilization of handpieces is one of the most rapid methods of sterilization. If proper cleaning and lubricating are performed as prescribed by the manufacturer, the usefulness of the instruments can be maintained with regular autoclaving. Fiberoptics tend to dim with repeated heat sterilization in several months to a year, apparently owing to oil residue and debris baked onto the ends of the optical fibers. Cleaning with detergent solution and wiping ends of optics with alcohol or other suitable organic solvents may prolong use before factory servicing. Manufacturers continue to improve the methods of preparing handpieces for sterilization. The manufacturer should be consulted for current advice and warnings.

**Other Methods of Handpiece Sterilization**

Chemical vapor pressure sterilization recommended for some types of handpieces apparently works well with ceramic-bearing handpieces, but it may impair others. One always must obtain the handpiece manufacturer’s recommendations. ETOX gas is the gentlest method of sterilization used for handpieces. Internal and external cleaning is important. Otherwise, preparation of handpieces before sterilization is not as critical because no heat is involved. In some types of ETOX sterilizers, gas seems to penetrate high-speed handpieces. Oil left in handpieces, however, can impair sterilization. Premarket review of the sterilizer and approval from the FDA for sterilizing handpieces must be confirmed with the manufacturer.

ETOX processing takes the handpiece out of circulation for several hours or overnight. Some practitioners have purchased an adequate number of low-cost handpieces to treat a maximum number of their patients per day and then use overnight ETOX sterilization. This approach may be effective with sufficient handpiece cleaning and disassembly. The FDA may not agree, however, with use of certain types of ETOX sterilizers for sterilizing handpieces. Further research on the effectiveness and any limitations of ETOX handpiece sterilization still may be needed. (Consult the manufacturer.) Dry heat sterilization of handpieces is generally not recommended.

**Infection Control for Impressions and Related Registrations Factors in Making Impressions and Associated Registrations to be Sent to a Remote Laboratory**

Precautions are required for infection control in making impressions and associated bite registrations. Universal barrier protection for personnel against contamination from mucosa, saliva, and blood by use of adequate PPE such as gloves, mask, and appropriate overgarment should be ensured. Before making the impression and associated bite registrations, clean, gloved hands should be used to dispense as many materials and disposable items as possible. This avoids contaminating the containers. Wiping material containers with a disinfectant after the procedures is the least satisfactory, but adequate, measure. An EPA-approved tuberculocidal disinfectant is considered satisfactory.

For infection control, custom resin trays for impressions made with nonaqueous rubber impression materials are used once and then discarded. Likewise, stock trays are used only for infection control, custom resin trays for impressions made with nonaqueous rubber impression materials are used once and then discarded. Likewise, stock trays are used only
once and discarded. The tray size is indicated on the patient’s chart to eliminate further try-ins.

**Concepts for Transporting Impressions and Associated Registrations to a Remote Laboratory**

Transport of impressions and associated bite registrations to a remote laboratory is regulated by OSHA’s specifications for handling and transporting specimens of blood or other potentially infectious materials: “Potentially infectious materials shall be placed in a container which prevents leakage during collection, handling, processing, storage, transport, or shipping (to the laboratory). Labeling or color coding is required when such specimens/containers leave the facility.” Controversy exists over two choices that may be used for preparing a potentially infectious item for transport: (1) Send it well cleaned (rinsed) and undisinfected in a biohazard-labeled, heat-sealed, plastic bag, or (2) debride, clean (rinse), and adequately disinfect it, place it in a sealed transport bag labeled with the precautions taken, and assume responsibility for the aseptic condition of the item. In either case, most laboratories disinfect the item (a second time in the second choice) to ensure protection of laboratory personnel. Disinfecting twice wastes time, and multiple exposures to disinfectant should be avoided. The National Association of Dental Laboratories recommends disinfecting all items received from the dental office and disinfecting all appliances before shipping them from the laboratory.

Inexpensive, biohazard-labeled, heat-sealable bags are commercially available in various sizes made of sturdy clear plastic, and they are stamped with warnings to transporters and personnel (Online Fig. 19–20). The U.S. Postal Service also has specifications for double, leak-proof packaging and external labeling of such packaging if contaminated items must be sent through the U.S. Postal Service. Similar bags are available for returning finished items to the office. They have no biohazard labels, but provide stamped instructions in green lettering advising office personnel that the contents are precleaned and disinfected and to handle the enclosed items appropriately for delivery to the patient (Online Fig. 19–21). Generic, heat-sealable bags are available, but these must be labeled appropriately.

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**Summary and Other Information Sources**

It is not possible to provide all the details on disease updates, tests, vaccines, barriers, standard operating procedures, sterilization methods, and equipment in one chapter, even one as comprehensive as this. Infection control and auxiliary personnel are referred to other, more detailed literature and texts provided in the reference list and are advised to attend continuing education programs to expand and update their infection control information.

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**References**


