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Disinfectants: Do They Work Equally Well?

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Disinfectants do not kill microorganisms equally well!

This message, and its implications, have failed to be understood. Clinicians, patients, and even manufacturers and infection control "experts" have chosen to ignore the fact that different disinfectant formulations have different antimicrobial activity. Some formulations do not kill much at all, while others have a rapid, broad spectrum kill. Yet, today any container labeled "disinfectant" is presumed by clinicians to kill everything, instantly and completely.

What has caused this gross misunderstanding? Many factors. First, and foremost, is the Environmental Protection Agency (EPA). Although it has the authority to control which disinfectants are sold within the U.S., it lacks a clear communication system to tell consumers what to expect from each

disinfectant. In addition, EPA does not test to confirm product claims. This results in a notorious manipulation of data as formulators attempt to imply all disinfectants kill everything.

The second factor is the overlapping role the Federal Drug Administration (FDA) shares with EPA in disinfectant control. Few clinicians understand why or how two different agencies are involved with the same issue. To add to the confusion, FDA verifies claims of sterilants (liquids that kill spores), but they do nothing to validate vegetative bacteria and virus kill. In addition to leaving gaping loopholes in their validation system, this selective testing confuses clinicians.

The third factor is the manufacturers and the marketing network. In the race to snare a portion of the multi-billion dollar disinfectant market, the major goal is to create unique products that can

	TB	POLIO
CHLORINES		
Without Blood	Green	Green
With Blood	Red	Green
ETHYL ALCOHOL (IF 70% - W/W, Airtight, Additives)		
Without Blood	Green	Green
With Blood	Green	Green
≥ 2% GLUTARALDEHYDE		
Without Blood	Green	Green
With Blood	Green	Green
IODOPHORS		
Without Blood	Red	Green
With Blood	Red	Red
ISOPROPYL ALCOHOL		
Without Blood	Green	Red
With Blood	Green	Red
PHENOLICS		
Without Blood	Green	Red
With Blood	Red	Red
QUARTERNARY COMPOUNDS		
Without Blood	Red	Red
With Blood	Red	Red

Fig. 1 Antimicrobial properties of seven major active ingredients in disinfectants used in dentistry. Green boxes indicate a consistent high kill (greater than or equal to 3 log₁₀ reduction) is achieved with the tuberculosis bacteria (TB) and poliovirus (polio) if human whole blood is, or is not, present. Red boxes indicate the kill parameters described previously are not achieved with this particular active ingredient.



Fig. 2 High ethyl alcohol/low phenolic environmental surface disinfectant products that consistently achieve high kill of tuberculosis bacteria and poliovirus in the presence of heavy human whole blood using the regimen shown in Figure 5.



Fig. 3 Glutaraldehyde (3.2 percent and 2 percent) for instrument immersion that consistently kill the tuberculosis bacteria and poliovirus in the presence of heavy bioburden in 40 and 60 minutes, respectively.

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generate high profit margins. The temptation to exaggerate is strong. This temptation is heightened by the gullibility of clinicians who blindly trust salespeople to choose their disinfectants for them. Knowing that clinicians place emphasis on cosmetics and cost rather than antimicrobial activity, salespeople naturally emphasize these things. After all, who wants to buy a potent disinfectant that smells like a potent disinfectant!

The fourth, and most subtle cause of misunderstanding about disinfectant potency, is misguided government agencies and "experts" who advise clinicians, but have never performed the microbiology testing to support their recommendations. Clinicians fail to notice this omission, and blindly follow without questioning and asking for documentation.

Because microorganisms are invisible, sources of contamination cannot be pinpointed by clinicians and, worse yet, effectiveness of disinfectants cannot be verified by clinicians. This allows the myth that all disinfectants perform equally well to continue unchecked. Is there a solution to the problem? If some products disinfect better than others, are there ways for clinicians to tell the difference? The answers are yes, and yes! Disinfectant performance is affected directly and profoundly by things clinicians can either control or learn to manage, such as:

- 1) Formulation;
- 2) Dilution;
- 3) Contact time;
- 4) Neutralizing sub-

stances (i.e.,: blood, plaque, saliva, etc.); and

5) Environmental conditions.

It is critical to realize that in the on-rush of clinical treatment many compromises occur in infection control. This problem will always be present. Therefore, highly potent disinfectants are needed to provide the margin of safety to compensate for less-than-perfect technique. In this context, it is important that every clinician understand the following simple basics of disinfectant why, where, which, and how.

Why Disinfect?

Clinically, is there really a transfer of infectious microorganisms? If so, why aren't we all sick? The truth is, most of us are less than totally well much of the time. When we do become ill, how does it happen? Does some angry god choose you to suffer, is it by chance, or is it because you came into contact with enough infected material that your immune system was overwhelmed? Unfortunately, direct and sure connection between infection and illness is always obscured by the incubation period — that quiet phase that occurs between infection and appearance of symptoms. It can last from days to years, depending on the type, virulence, and number of infectious invaders, and the host's immune status. It would require a virtually perfect memory for people to recall all sources of possible infection by the time symptoms finally appear. In addition, infectious sources can be extremely subtle, such as inspiration of aerosols or



FIG. 4 Comparison of EPA Registration Numbers on disinfectants shows which packages contain identical formulations. Compare the group of numbers before and after the first hyphen or space. If they are identical, the formulations are identical. Ignore the numbers after the second hyphen or space. By U.S. law, all products claiming disinfection must have EPA registration displayed somewhere on the package label.



Fig. 5 Wiping of environmental surfaces to clean spreads contaminated matter over a broader area, and causes someone in the office to be exposed to patient's potentially infectious body fluids at a time when organisms are most likely to be viable, therefore, we recommend cleaning with a disinfectant, not before applying a disinfectant.

direct contact with clean-appearing objects or contact with people who are infectious but do not appear to be ill.

Major pathways of infection are demonstrable. For example, years ago, before *Serratia marcescens* was identified as an opportunistic pathogen, it was used commonly to demonstrate principles of organism transfer to microbiology students. The exercise entailed pipetting a small drop of organisms in suspension into one student's hand. Then all students in the lab shook hands in a chain reaction. Culture of all the students' hands revealed

the telltale red colonies on every person in the lab. Thus, 20-plus people were contaminated from one drop of organism suspension on one person's hand! Recently, Mbithi, et al., demonstrated the same type of hand transfer of infectious organisms using hepatitis A.¹ They showed clearly that transfer occurs from hand to hand, hand to object, and object to hand. Years earlier, Gwaltney, et al., isolated healthy human volunteers and demonstrated transfer of rhinovirus colds via infected tiles and cup handles.² To investigate possibilities of infectious disease transfer in dental settings,

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Belting, et al., cut cavity preparations on sputum positive tuberculosis patients and recovered enough organisms in aerosols to infect attending clinicians.³ In addition, there have been documented transfers of both hepatitis B and herpes in dental environments.^{4,5}

Most recently, in our own laboratory, we saw how far-reaching infectious disease transfer can be. A culture of *Staphylococcus aureus* test organisms was transferred from a master die, to impressions, to stone dies,

to dust retrieved during trimming of die margins! The test organisms not only survived three transfers (master die to impression to stone), but also survived two extended bench wait periods (one hour after pouring dies before separation from the impression and 18 hours after separation before trimming margins).

Clinicians believe it — diseases of microbial origin are caused by the insidious, invisible transfer of microscopic agents in air, water, food, dental materials, and from sur-

faces of all types. Microorganisms are resilient, tenacious, and stubbornly viable. They can remain infectious on dry, clean-appearing surfaces for long periods of time, and be passed uneventfully to unsuspecting people.

Where Disinfect?

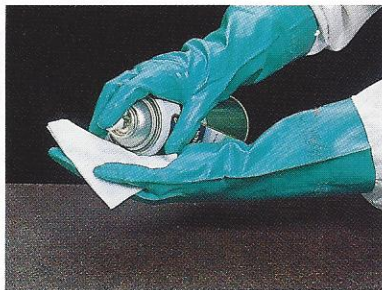
Some items used routinely in dental treatment cannot be sterilized with heat or covered with plastic. Impressions, cuspidors, and sinks are common and obvious exceptions. Also, some items need to be pretreated to

lower organism loads before handling to clean and wrap before sterilization. Hence, the answer to where disinfectants are necessary is: 1) for impressions and other items that do not tolerate heat, 2) for environmental surfaces that cannot be covered, and 3) for pre-disinfection of items coated with patients' body fluids that are to be handled by clinicians to process before sterilizing.

Which Disinfectants?

Are there ways clinicians can determine which

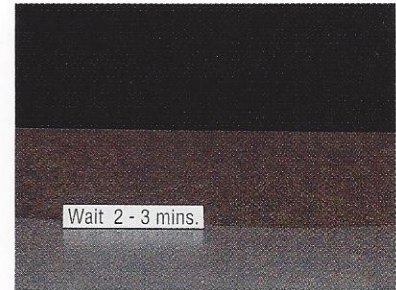
Figs 6a thru 6i - Steps in environmental surface disinfection.



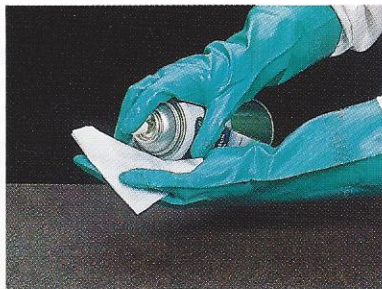
6a. Wet applicator thoroughly with disinfectant, holding the dispenser close to minimize aerosols.



6b. Apply disinfectant liberally to the contaminated surface. Re-wet the applicator as needed.



6c. Wait for two to three minutes to allow contact time for the disinfectant to penetrate any biofilm and kill the microorganisms.



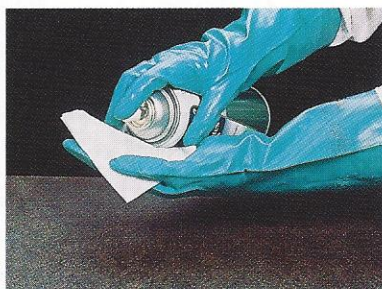
6d. wet a second applicator thoroughly.



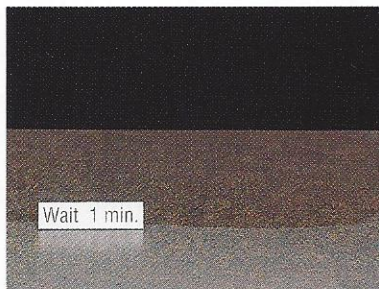
6e. Use second applicator to scrub the surfaces to remove visible debris.



6f. wet a third applicator.



6g. Re-apply a liberal coating of disinfectant onto the surface.



6h. Allow at least one minute contact time



6i. Wipe dry with a clean paper towel.

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disinfectants are effective? Yes! The following information is required on labels of disinfectants sold in the U.S. and provides important clues:

- 1) Name of active ingredient(s);
- 2) Amount of active ingredient(s); and
- 3) EPA registration number.

The most important clue to disinfectant potency is name of the active ingredient(s). However, very few clinicians know the meaning of this information. Clinicians need to know there are currently seven major active ingredients used for disinfectants in dentistry worldwide. They are

- 1) chlorine,
- 2) ethyl alcohol,
- 3) glutaraldehyde,
- 4) iodophors and iodines,
- 5) isopropyl alcohol,
- 6) phenolics, and
- 7) quaternary ammonium compounds.

A pattern of kill potential for the seven active ingredients emerges that is consistent and repeatable when they are tested separately, at valid dilutions, against resistant bacteria and viruses such as the tuberculosis bacteria and poliovirus, both in the absence and presence of clinically relevant neutralizing proteins, such as whole blood. Figure 1 gives an important summary of what can be expected from the seven major active ingredients in disinfectants. It summarizes hundreds of tests performed at CRA over the past 17 years. Test protocols and details are available in previous publications.⁶⁻¹² These data show that only high ethyl alcohol/phenolic formulations (Fig. 2) and greater

than or equal to 2 percent glutaraldehydes (Fig. 3) give consistent kill both in the absence and presence of blood. These two active ingredients have opposite clinical indications. High ethyl alcohol/phenolic formulations (greater than or equal to 70 percent w/w or greater than or equal to 80 percent v/v with less than or equal to 1 percent phenolic) are indicated for environmental surfaces, but should not be used for instrument immersion because the alcohol volatilizes in containers that are not air-tight, and antimicrobial activity is lost. Glutaraldehyde (greater than or equal to 2 percent) is indicated for instrument soaking, but should not be used on environmental surfaces because it can produce hypersensitivity reactions and release aldehydes.

CRA includes whole blood in all tests of active ingredient efficacy because clinicians never deal with pure cultures of microorganisms. Clinically, microorganisms are always contained within human material such as blood, plaque, calculus, saliva, crevicular fluid, etc. Since these complex proteins interfere with the antimicrobial activity of all disinfectants, it is imperative to include these proteins in tests to discover which disinfectants can overcome their neutralizing influence. Clinicians must beware of data on disinfectant potency that does not include clinically relevant protein contaminants and resistant microorganisms.

Amount of active ingredient(s) is a second important clue to disinfectant potency. Different active ingredients perform opti-

mally at different dilutions, and combinations of two or more active ingredients can create new parameters. Clinicians should remember that over-dilution always decreases the antimicrobial activity of all active ingredients. Over-dilution has been a serious problem, and this problem still persists today. The concept of diluting a disinfectant has tremendous appeal to both manufacturers and clinicians. Both view it as a way to economize. Ideally, disinfectants should be sold only at optimum concentration. Unfortunately, this is not what happens. Clinicians have absolutely no way to know a product's optimum dilution. Therefore, disinfectants that allow in-office water dilution should be handled with great care in following proportioning directions.

EPA registration number is a third important clue to disinfectant potency. Clinically, its greatest importance is in helping to recognize identical formulations in different containers. If the groups of digits before and after the first hyphen are identical, the formulations are identical. Figure 4 illustrates this concept. Understanding that the same disinfectant formulation can appear in many different packagings can be important in identifying different brand names with identical antimicrobial properties, and in avoiding paying more for the same thing.

The EPA registration number also indicates that information concerning the product has been submitted by the manufacturer to EPA, and duly

processed. If all data produced in manufacturer's labs and commercial test labs could be trusted, and if it was validated by an EPA lab, both initially and at regular intervals thereafter, then EPA registration would be extremely meaningful to clinicians. However, this is not the case. EPA's registration system became a much publicized fiasco when the U.S. government's General Accounting Office (GAO) conducted an investigation of EPA in 1990. The title of the GAO's final report summarizes their findings: "EPA Lacks Assurance Disinfectants Work."¹³ Without an EPA lab to validate claims, there will always be discrepancies between disinfectant claims and actual performance. Clinicians beware! You are spending the money and time with the belief you are achieving rapid, thorough kill of resistant microorganisms. Unless you are using high ethyl alcohol/phenolic formulations or greater than or equal to 2 percent glutaraldehydes, you are not achieving your goal!

Other clues such as listings of organisms killed by the disinfectant and contact times required should be noted, but clinicians should be aware that these data may not be reliable. Do not be fooled by long lists of easy to kill organisms. Instead, look for names of two key organisms known to be resistant to kill — *Mycobacterium tuberculosis* and poliovirus. If they are not listed on the product label, the disinfectant is probably not effective against them. As far as contact time is concerned, there is an erroneous

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impression that 10 minutes is a sacred number. However, there is no one time that is appropriate for all disinfectants in all situations. For example, the high ethyl alcohol/phenolic formulations are very rapid acting, and kill even the resistant tuberculosis bacteria and poliovirus in the presence of heavy

blood contamination within two to three minutes. The greater than or equal to 2 percent glutaraldehydes also kill poliovirus rapidly, but require extensive time periods to kill the tuberculosis bacteria (40 to 60-plus minutes). Kill time depends on disinfectant concentration and

specific formulation, as well as many clinical variables such as type and amount of organism challenge, type and amount of bioburden present, room temperature and humidity, etc. Because clinicians want disinfectants to work rapidly, companies often try to claim shorter times than are clinically safe. Because clinicians do not understand that disinfectants need time to react with microorganisms to kill them, they often remove the disinfectant before it has accomplished its kill. A good "rule of thumb" is: Longer contact times deliver more thorough kill.

with care. Effective barriers such as eye covering, face mask, utility gloves, and protective clothing should be worn. Also, ample fresh air should be circulated, and techniques should be used to minimize formation of disinfectant aerosols.

Although all the "experts" for years have advised thorough cleaning before use of disinfectants, clinically, this makes absolutely no sense. It forces someone to touch contaminated items when organisms are most likely to be viable. The danger is further enhanced by spreading infectious material during wiping (Fig. 5). Cleaning should be done with a disinfectant, not before applying a disinfectant.

Figure 5 illustrates steps in the use of a high ethyl alcohol-phenolic en-

Figs 7a thru 7d - Steps in processing of loose and cassette stored instruments.



7a. After treatment and before handling, Pre-disinfect all loose instruments by placing directly into 3.2 percent glutaraldehyde for 40 minutes to decontaminate before touching, then rinse.

How to Use Disinfectants

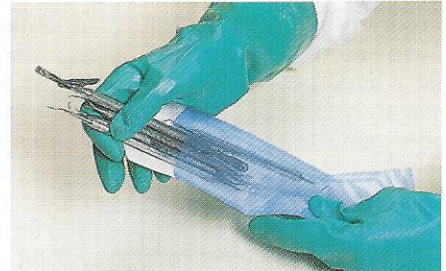
Disinfectants are designed to kill microbial cells. They should be considered toxic and handled



7b. Transfer instruments to a powerful ultrasonic cleaner and operate at least 1.5 minutes per instrument for loose instruments and at least 15 minutes total for instruments within a cassette, then rinse.



7c. Dry instruments, whether loose or in a cassette, in a hot air dryer (ESMA) to avoid rusting if they are to be sterilized in a chemical vapor or dry heat sterilizer.



7d. Wrap loose instruments or cassettes and sterilize.

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vironmental surface disinfectant that includes pre-disinfection to lower organism counts, clearing away of visible debris using the disinfectant as the cleaner, and the final disinfection following removal of visible debris. The steps include:

1. Pre-disinfect

a. Wet an applicator thoroughly with disinfectant, holding the dispenser close to minimize aerosols.

b. Apply disinfectant liberally to the contaminated surface. Re-wet the applicator as needed.

c. Wait for two to three minutes to allow contact time for the disinfectant to penetrate any bio burden and kill the microorganisms.

2. Clean.

a. Wet a second applicator thoroughly, use it to scrub the surfaces to remove visible debris, and

discard the applicator.

3. Disinfect

a. Wet a third applicator and reapply a liberal coating of disinfectant onto the surface.

b. Allow at least one minute contact time, and wipe dry with a clean paper towel.

When using glutaraldehyde for immersion disinfection, Figure 6 illustrates the steps. Briefly, they include:

1. Pre-disinfect (This step is not necessary if instrument cassettes are used.)

a. After treatment and before handling, place all loose instruments directly into 3.2 percent glutaraldehyde for 40 minutes, then rinse.

2. Clean

a. Transfer instruments to a powerful ultrasonic cleaner (CRA tests show Coltene/Whaledent and Health Sonics curren-

ly manufacture the most effective ultrasonic cleaners) and operate at least 1.5 minutes per instrument for loose instruments and at least 15 minutes total for instruments within a cassette, then rinse.

3. Sterilize or final disinfect.

a. Dry instruments, whether loose or in a cassette, in a hot air dryer (ESMA) to avoid rusting if they are to be sterilized in a chemical vapor or dry heat sterilizer.

b. Wrap loose instruments or cassettes and sterilize. If items cannot be heat sterilized, instead of wrapping at this point, immerse in 2 percent glutaraldehyde for 60 minutes to final disinfect or for 10 hours to sterilize.

Conclusions

It is critical for clinicians to realize that all disinfectants do not kill

microorganisms equally well. It is also critical to know what can be expected, in terms of microbial kill, from each of the seven major active ingredients used in dentistry (Fig. 1). Today, infection control expectations in healthcare environments demand use of only those disinfectants that deliver consistently rapid, broad spectrum kill of resistant microorganisms in the presence of heavy protein such as blood and saliva. Hundreds of tests on disinfectants performed by CRA over the past 17 years have shown that only two active ingredients meet these demands: high ethyl alcohol/phenolic formulations for environmental surfaces and greater than or equal to 2 percent glutaraldehydes for instrument immersion. ♦

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