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The purpose **of disinfection**

The importance of disinfection in medicine can be traced back to Ignaz Semmelweis. As early as 1850, he proposed the hypothesis that puerperal fever is contagious and that the incidence of women falling ill could be greatly reduced by doctors and students disinfecting their hands with chlorinated lime water. J. Lister, one of the co-founders of aseptic surgery, introduced the chemical disinfectant phenol, which was used to disinfect surgical instruments.

Before sterilization takes place, reprocessed instruments and medical devices must be inspected for cleanliness and proper function, and assembled if necessary. Post-cleaning disinfection grants a sufficient level of infection protection to the staff member responsible for the inspection, assembly and functionality testing of instruments and devices.

The purpose of disinfection is to reduce disease-causing germs in such a way that any potential infection chain can be interrupted, and the germ count is kept as low as possible. With a **log reduction** of 5, no more than 10 out of 1,000,000 reproductive germs survive.

In EN ISO 15883-1 (2014), disinfection with respect to medical instruments is defined as follows:

Disinfection results in a reduction of the number of viable micro-organisms on a product or instrument to a level that has been specified beforehand. This level corresponds to the intended further handling or use of the product.

Important note: To protect medical products and instruments from potential damage and to ensure that their functionality is maintained, please ensure you always observe the manufacturer's instructions for processing (1).

A disinfection effect can be achieved by means of chemical or physical processes; some processes can be combined, such as in thermochemical processing.
As always, the following information applies: Devices or instruments that are going to be disinfected (or sterilized) must first be cleaned. This ensures that the disinfectant will be able to fully cover the device or instrument.

The mode of action of thermal disinfection entails the killing or destruction of germs by means of heat or moist heat. Where possible, preference should always be given to thermal processes over chemical processes. **Thermal processes** are easier to **validate** and monitor during the disinfection process. Staff exposure to adverse health and safety effects from chemical processes is substantially higher compared to thermal disinfection. The environmental impact with regard to chemical waste disposal is also of importance here. Compared with manual chemical disinfection, thermal disinfection distinguishes itself as the leading-edge process due to its stable performance and low error rate.

Preference should be given to thermal washer disinfectors offering automated cleaning and thermal disinfection processes. Indeed, the performance of both processes can be easily verified, validated and documented. This is not possible with manual processes. The risk of errors in the concentration of products, the contact/action times, etc. are virtually zero compared to manual methods. Finally, staff is much less exposed to the risk of infections due to handling that is kept to a minimum.

Chemical disinfection processes are carried out manually in general dental practice. Depending on the effectiveness of the disinfectant in question, and on the disinfectant resistance of particular germs, the level of germ reduction can vary (2).

Literature:
(1) ISO 17664
(2) WHO Library Cataloguing-in-Publication Data, Decontamination and reprocessing of medical devices for health-care facilities. World Health Organization. II. Pan American Health Organization. ISBN 978 92 4 154985 1

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What's about **manual disinfection** and its effectiveness?

Although automated washer disinfectors provide a more reliable and economic method of thermal disinfection, there may be occasions when thermal disinfection processes can not be conducted. In some cases it is maybe necessary to use chemical disinfection, but only for certain categories of instruments and NOT as a substitute for steam sterilization.

For manual disinfection of dental instruments you need disinfection which is all bactericidal, tuberculocidal, fungicidal and virucidal (definitions see below) against all enveloped and non-enveloped viruses. It should also work quickly, and protect surfaces and instruments.

Dry heat sterilization and chemicals are not recommended for the routine sterilization of dental instruments and equipment. Ultraviolet light and boiling water do not sterilize instruments and must not be used (1).

To help protect the environment and protect yourself from harmful disinfectant, thermal disinfection or steam sterilization can be the right choice to substitute chemical disinfection, which could harm personal and instruments.

Important note: Before you buy any new instruments or dental devices, always check the manufacturers instructions and the compatibility of those instructions with your existing decontamination processes. Always observe the specific manufacturer's information with regard to whether chemical disinfection processes are compatible with the instrument. Incompatibilities can substantially reduce the lifespan of an instrument or considerably limit its function and provide a risk of cross-infection to patients.

How and where do chemical disinfectants take effect?

Chemical disinfectants contain active substances that inactivate or kill germs. Among other things, this effect is based on the chemical disinfectant's ability to destroy or inactivate the microbial cell wall, or to inhibit certain metabolic processes of the germs resulting in cell death.

Good to know: the effect depends on the **resilience** and **resistance** of the germs, the correct concentration of the agent used, the exposure time, bioburden and the temperature. If these factors are not taken into account when using disinfectants, then the killing effect is less reliable. If disinfectants are mixed together or if a liquid disinfectant is used in a manner that does not comply with the manufacturer's instructions, then a disinfectant effect will no longer be achieved. The instruments and medical devices must be fully immersed in the liquid disinfectant.

Each disinfectant has its own range of action that is restricted to specific germs. The range of action determines which germs can be killed or inactivated.

Dental practices must therefore use disinfectants that have a suitable range of action (bacteria, fungi, viruses). There are specific tests that disinfectants must meet in order to make claims of disinfectant activity against specific pathogens (e.g. EN 1276, EN 14476, EN 13624 and EN 13704 (sporicidal)). Although the range of action can be found on every product label, it is important to check that any product meets the relevant standard. In addition, every disinfectant has its own specific application requirements; these must be followed according to both the disinfectant supplier and instrument manufacturer, otherwise the maximum effect is not guaranteed and risks of **cross-infection** may occur. The instructions for using disinfectants must be specified in the dental practice operating procedures, chemical hazard risk assessment and documentation of the practice staff training as per each country Health and Safety at Work legislation.

A distinction is drawn between the following modes of action (1), depending on the germ type (e.g. bacteria, fungi, viruses, listed alphabetically)

Bactericidal:	Destructive against vegetative bacteria (e.g. Meningococci, MRSA, Salmonellae). 'Vegetative' here means 'alive' (in contrast to bacteria spores – see 'Sporicidal').
Fungicidal:	Destructive against fungi (e.g. mould).
Yeasticidal:	Destructive against yeast fungi (e.g. Candida albicans).
Mycobactericidal:	Destructive against mycobacteria (Mycobacterium tuberculosis – causative agent of tuberculosis).

Partially virucidal:	Destructive against enveloped viruses (e.g. SARS-CoV-2, HIV, Hepatitis B viruses, Hepatitis C viruses).
Sporicidal:	Destructive against spores from bacteria such as C. difficile. Spores are highly resistant permanent forms of certain types of bacteria.
Tuberculocidal:	Destructive against tuberculosis bacteria.
Virucidal:	Destructive against all viruses, i.e. enveloped and all non-enveloped viruses.

Disinfectants can be categorized into different levels depending on their ability to kill germs.

Categories are:

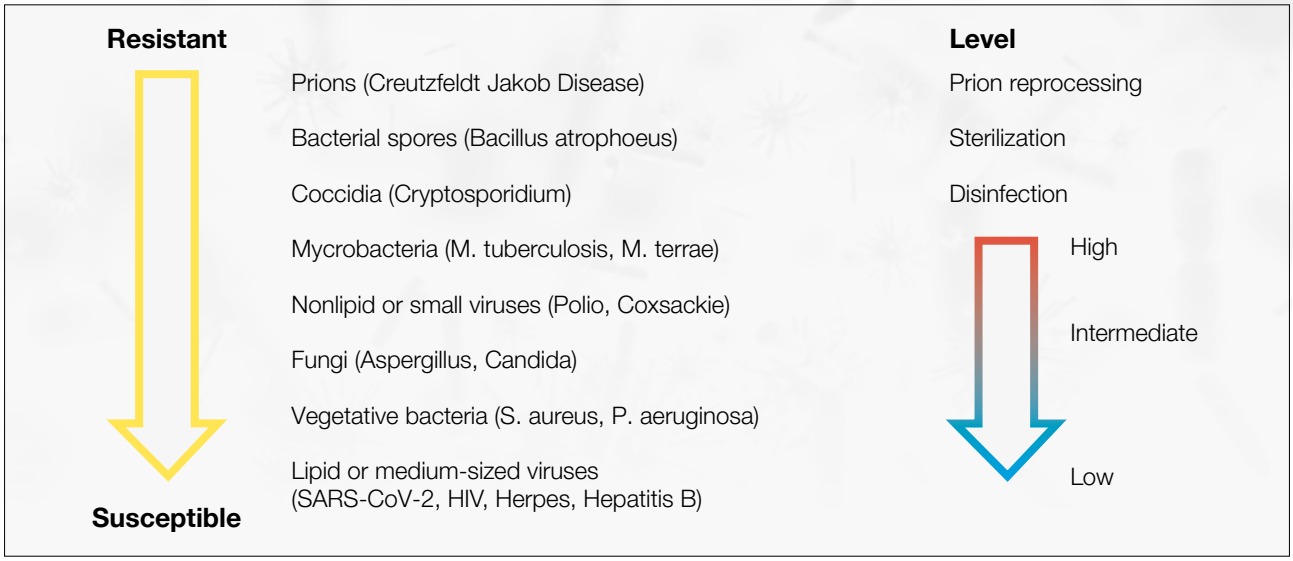
WHO categories:

High level:	(HLD) Kills all vegetative microorganisms, mycobacteria, lipid and non-lipid viruses, fungi spores and some bacteria spores. One example of a high level disinfectant is peracetic acid, these groups of compounds are unsuitable for use in dental practice because of their highly toxic nature and health and safety control required to use them.
Mid level:	Kills mycobacteria and most viruses and bacteria. It is registered by the Environmental Protection Agency (EPA) as a 'tuberculocide'. If used in dentistry, this is not a substitute for thermal sterilization.
Low level:	Kills some viruses and bacteria.

RKI categories
(only Germany, based on the Robert Koch Institute) (3):

Range A:	Vegetative cells from bacteria, mycobacteria and fungi. Spores from pathogenic fungi are also killed.
Effect area B:	Killing viruses
Activity range C:	Killing spores of low resistance (anthrax)
Activity range D:	The largest effective range. Killing heat-resistant spores of bacteria, especially spores of clostridia.

Table 1.:
Adapted data from WHO Library Cataloguing-in-Publication Data: the diagram (1) shows the more or less susceptible germs for each appropriate disinfection level.



Based on the grading of medical instruments and products by **Spaulding**, which assign instruments to different grades based on their contact with the patient or infectious material, the required disinfectant of the relevant level is to be used. Chemical disinfectants are a poor substitute for steam sterilization and MUST NOT be used in place of steam sterilization for critical or semi-critical devices.

When handling chemical disinfectants, they must always be handled, stored, applied and disposed appropriately. Make sure you always wear protective clothing, gloves and protective eye wear. You should also observe the corresponding safety and disposal information provided by the disinfectant manufacturer. Please note that other important health and safety information such as, risk assessments, occupational health monitoring, record keeping, storage, and access of disinfectants should be known and followed (2).

After chemical disinfection has taken place, devices should be free from microbial contaminants. Any remaining disinfectant should be rinsed off using purified water (the water used should be suitable for clinical use). Disinfectant residues and components of dead germs, such as endotoxin, can trigger reactions that are harmful to health if they come into contact with patients (2).

Bibliography:
(1) WHO Library Cataloguing-in-Publication Data, Decontamination and reprocessing of medical devices for health-care facilities. World Health Organization. II. Pan American Health Organization. ISBN 978 92 4 154985 1
(2) Nizam Damani, Manual of Infection Prevention and Control, fourth edition, Oxford University Press, ISBN 978-0-19-881593-8
(3) https://edoc.rki.de/bitstream/handle/176904/5723/2017_Article_ListeDerVomRobertKoch-Institut.pdf?sequence=1&isAllowed=y, last view 22.07.2020

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Thermal reduction

Destruction of microorganisms

Key facts

- Heat is the most reliable means of inactivating/ killing microorganisms
- Microorganisms show high variability in heat tolerance
- Thermal reduction is mathematically described as a logarithmic process

Heat as a means of inactivation or rather destruction of **microorganisms** can either be applied as moist or dry heat. Both methods are reliable but when applicable moist heat is more effective as steam is a better heat conductor than air and thus exposure times shorten significantly because proteins lose their functionality more readily in moist conditions [1].

Microbial heat resistance

Each microbial species has its own particular heat tolerance. Important variants in microbial resistance are the composition of the outer membrane, metabolism and developmental stage of the microbial organism. Outer membranes vary in their chemical composition not only across species but also during developmental stages e.g. spores and resting stages which are encased in special hulls to protect the organism from external influences. Viruses have no metabolism of their own and are dependent on their host's cells to replicate, so there is no metabolic activity to be targeted. Furthermore, contrary to other microorganisms viruses without an outer protein hull are more resistant than enveloped ones [2, 3].

The principle of heat destruction

Heat targets proteins. These essential biomolecules are sensitive to temperature and start losing their functionality at 55°C, dependent on composition and intermolecular binding. This process is called **denaturation** and is based on breaking and rebonding on a molecular structural level. Once the native structure of a protein is destroyed through the process of denaturation it cannot be reassembled to regain its biological activity [1].

The thermal death time curve and the D-value

Killing microorganisms is a time and temperature dependent process which results in a thermal death time curve for each organism. The process of microbial elimination by means of heat follows a logarithmic procession (see also **logarithm, exponentiation**). Meaning that during each passing time unit at a certain temperature the number of viable bacteria will be reduced by the same percentage, regardless of the number of bacteria. Also, by altering the applied temperature, holding times shorten or lengthen respectively. Consequently, anywhere along a death time curve represents the same degree of lethality [2].

Based on this dependence the **D-value** (decimal reduction time) has been defined as the necessary holding time, at a certain temperature, to eliminate 90% of a microbial population, thus can be determined for different microbial species and temperatures [2, 3]. Hence the D-value serves as parameter in evaluating and monitoring sterilisation procedures.

Bacteria species	Temperature (°C)	D-value (time)
Salmonella thyphi	65	1 s
Vibrio cholerae	65	3 s
Mycobacterium tuberculosis	75	5 s
Staphylococcus aureus	80	2 s
Bacillus anthracis	100	15 min
Bacillus stearothermophilus (endospores)	121 (121/134)	2-5 min (15/3 min)
Clostridium botulinum A and B	121	10-20 s
Endospores C. botulinum	120	20 min
Endospores C. tetani	134	3 min

The table shows selected bacteria species or developmental stages and their respective D-values at defined temperatures e.g. when a temperature of 65°C is applied to a population of Vibrio cholerae 90% of the present population will be killed off after 3s.

Bibliography:
[1] ÖSGV Fachkundelehrgang: Weiterbildung Sterilgutversorgung – Grundlagen der Aufbereitung von Medizinprodukten
[2] Thermal destruction of microorganisms, Article by Goff D. University of Guelph
[3] ÖSGV Fachkundelehrgang: Weiterbildung Sterilgutversorgung – Grundlagen der Sterilisation
[4] Medizinische Mikrobiologie und Infektiologie, Kapitel Sterilisation und Desinfektion

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Is **disinfection** or **sterilization** required ?

Whether, and when, disinfection and sterilization should be performed during reprocessing relates to the **Spaulding** classification. Dr Earle Spaulding proposed three categories of medical devices that are based on a medical device's potential for transmitting infections, linked to the level of decontamination required e.g. disinfection (high, medium and low level). This is a rational approach to disinfection and sterilization of patient-care items and equipment. The contamination results from various residues which are listed in the following.

Risks can occur as a result of e.g.:

- Residues from previous applications (e.g. blood, blood components, secretions, excretions and other body parts, medications);
- Residues from previous reprocessing (e.g. detergents, disinfectants, sterilization agents and other agents, including their reaction products);
- Changes to the physical, chemical or functional properties of the medical device or
- Changes to the condition of the material (e.g. accelerated material wear, embrittlement and altered surface properties, changes to contact points and connections, e.g. from bonding, welding, pressing).

W&H recommends:

- to always apply sterilization and
- to pouch or wrap any instruments which will come in touch with the patient.

W&H recommends this in order to reduce the risk of infection and to simplify the process. When all the instruments follow the same procedure, safer conditions for the patient are provided. Human errors in terms of logistics could e.g. lead to an incident, that one instrument that was reprocessed for an application (semicritical or non-critical) is used for a critical application (mirrors, probes handpieces, etc. …). In such a case the advantage of avoiding sterilization reprocessing is much more irrelevant than the possible risk of a cross-infection.

Important note:

To protect medical products and instruments from potential damage and to ensure that their functionality is maintained, please ensure you always observe the manufacturer's instructions for processing. Manufacturers of medical devices and instruments are obliged to provide instructions for use that comply with EN ISO 17664. These instructions must contain validated preparation processes for the respective medical device.

All dental handpieces and accessories should always be heat sterilized between patients and should not be subjected to high-grade or surface disinfection. This is because although these devices are classified as semi-critical and their sterilization is therefore not mandatory, studies have shown that their internal surfaces can be contaminated. If such devices are only disinfected, patients can become contaminated with the potentially infectious materials inside the instrument. The easiest way and to be on the safe side would be to sterilize the dental instruments in a **steam sterilizer**.

The table below provides a rough division of the classification of reprocessable instruments with the associated recommended decontamination level required. In some countries, the Spaulding classification has been refined in more sophisticated classes. Therefore please refer to your national classification guide.

Table 1: Classification from Spaulding

Classification	Type of procedure	Level of decontamination required
Critical	Invasive devices that enter tissue or enters the vascular system, e.g. extraction forceps	Sterilization
Semi-critical	Device contacts intact mucous membrane but does not penetrate tissue, e.g. dental mirrors	High level disinfection* (sterilization preferred where practicable)
Non-critical	Device only contacts intact skin	Can be processed by cleaning (& low level disinfection where necessary)

* High level disinfection is a process designed to kill vegetative microorganisms, mycobacteria, viruses, fungal spores and some but not all bacterial spores. An example of a high level disinfectant is peracetic acid, these groups of compounds are unsuitable for use in dental practice because of their highly toxic nature and health and safety control required to use them.

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Drying – Reason why

At first glance, the importance of drying seems difficult to understand why it is mentioned in the **decontamination** cycle. This stage was initially identified in large sterilization departments, as it was found that it could lead to wet packs of surgical instrument trays. In todays modern dental surgery it is an important quality control measure as visible droplets of water remaining on/in instruments may lead to wet packs that no longer maintain their sterile barrier function (1). Water drops inside lumens may block penetration of steam. In addition, soaking wet instruments are more difficult to determine if they are clean. In some areas, if hard water is not rinsed off with purified water and then dried, limescale deposits may also appear. By drying instruments deposits and limescale deposits will be avoided, which in addition prolong the life span of the instruments.

Recommendations for correct drying

(please always follow the manufacturer's instructions)

The procedure used for drying should not only be quick and reliable, it should also prevent fresh contamination with chemical, microbial and particulate elements. **Ideally,** drying should be performed as part of the **automated cycle** in a **washer disinfector.** This is usually accomplished at the end of the thermal disinfect stage where the heat from the instruments can be used to 'flash off" any residual water. This is often assisted by a fan in the washer. Failing this, then drying shall be accomplished manually as quickly as possible after washing (see manual drying below).

Manual drying

Instruments should be dried by hand with a clean, lint-free cloth. Instrument cavities should be dried by means of compressed air, using the pressure specified by the device manufacturer. To avoid staining, metal instruments should be dried after they have been washed.

Literature:
(1) Debabrata Basu; Journal of Infection and Public Health Volume 10, Issue 2, March–April 2017, Pages 235-239