# PRINCIPLES OF HEAT STERILIZATION IN DENTAL PRACTICE

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## Introduction

Sterilization is defined as the destruction of all forms of life including sporing forms of microorganisms such as Clostridium tetani, whilst disinfection on the other hand is a method of destroying pathogenic non-sporing microorganisms. Disinfection is strongly associated with chemical agents (disinfectants) but other methods such as heat (100°C) are more reliable to ensure disinfection.

Chemical disinfectants suffer the drawback of unpredictable killing power with changes of concentration, temperature, pH, decomposition with time and in the presence of blood, pus or other organic material (1-4). Some gases eg. formaldehyde and ethylene oxide are being used in large sterilization units in hospitals and in factories, but these techniques are not feasible in dental practice. Another method used on industrial scale for the manufacturing of disposable plastics, gloves, syringes and catheters is sterilization by ionizing radiation.

The most efficient and reliable method of sterilization and disinfection in dental practice is by heat, with or without steam.

## Sterilization by steam

The temperature at which water boils and steam is formed depends on the air pressure. Under normal conditions at sea level the temperature of steam is 100°C. Steam is more effective in conducting heat than hot dry air of the same temperature and hence the exposure time for sterilization with steam is much shorter than with dry hot air.

One condition is required to ensure proper steam sterilization. Since steam does not readily mix with air, layering may occur in the steam container or steam may not penetrate into the load of instruments and dressings because of the presence of entrapped air. A steam sterilizing device should therefore be constructed in such a way that air can be displaced by steam and instruments should not be enclosed in sealed boxes or heavily packed so that steam cannot penetrate. Specially made sterilization pouches for instruments are penetrable for steam. These pouches provide the advantage of aseptic storage of instruments when kept in the pouches. However they are expensive and not really necessary.

## Autoclave

An autoclave is a metal vessel with a sealed door that allows steam to enter and accumulate whereby the pressure increases and consequently the temperature. There are in principle two types of autoclaves. One with a vacuum device and one without. The type that creates vacuum in the chamber before steam enters ensures penetration of steam in all corners and in the load of the pack. This is a superb but expensive apparatus. An autoclave without vacuum is commonly used in dentistry. To ensure penetration of steam in all compartments in the chamber, the principle of downward displacement of air by steam that enters at the top of the chamber is used. These type of autoclaves should always be equipped with perforated shelves to ease the downward displacement of air by steam.

Accumulation of steam in the chamber of the autoclave results in increased pressure and temperature. Table 1 shows the relationship

Table 1. Pressure, temperature, exposure time and overall working cycle time of an autoclave.

| Pressure (psi) | Temperature (°C) | Exposure time (min) | Total working cycle time (min) |
|---|---|---|---|
| 10 | 115 | 30 | 40 -50 |
| 15 | 121 | 15 | 25 - 35 |
| 30 | 134 | 3 | 13 - 20 |

between pressure and temperature and further presents the exposure time (time needed to kill all microorganisms at a certain temperature) and the overall working cycle time (heat up time + exposure time + cooling time). The total working cycle time depends on the type of apparatus.

**Pressure cooker**

A good alternative for the autoclave is the pressure cooker, which is based on the same principle: steam accumulation, higher pressure and higher temperature. In contrast to the autoclave with downward displacement of air, the pressure cooker operates with upward displacement of air by steam. Pressure cookers are much cheaper than autoclaves. Those particularly designed for medical use are preferable since they have an automatic timer for the working cycle and because they are equipped with handy containers for instruments. The pressure cooker should have perforated containers and shelves. Instruments should not be packed in closed boxes in the pressure cooker since steam cannot penetrate the box. Exposure to steam is a prerequisite for reliable sterilization and therefore the pressure cooker should be used properly. It means that weights intended to increase the inner pressure and consequently the temperature, should not be placed on the opening in the lid before steam is formed in the chamber, otherwise air will be entrapped inside and steam does not mix easily with air. Allow steam to replace air by pushing it out through the opening of the lid for at least 2 minutes before placing the weights on the opening.

**Burs, mouthmirrors and handpieces**

As reliable as autoclaving can be, the procedure corrodes and dulls carbon steel burs and carbon steel instruments and it causes rust that particularly affects mouth mirrors. A 1% sodium nitrite solution that vaporizes in the autoclave can protect metal from oxidation by hydrolysis. Another way to deal with this problem is to sterilize carbon steel items and mouthmirrors in the dry heat oven.

Sterilization of handpieces between patients is internationally recommended. Handpieces must be thoroughly cleaned to remove the organic debris and lubricated before sterilization. For those handpieces that cannot withstand heat, the Centers for Disease Control in the USA has outlined a compromise protocol: Handpieces should be scrubbed with a detergent and water and then wrapped in a paper towel or gauze impregnated with an effective disinfectant (iodophors, glutaraldehyde 2%, chlorhexidine 0.5% in 70% alcohol or savlon 3.3% in 70% alcohol). Exposure to the disinfectant should be according to the recommended time for that disinfectant. Afterwards chemical residue should be removed by rinsing with water.

**Chemiclave**

Many dental practices in Europe are now equipped with a chemiclave. The principle is exposure of the instruments to chemical vapour at 130°C., which means under pressure with 20 psi. The chemical agent is a combination of formaldehyde, alcohols, acetone, ketones and steam. The major advantages of the chemiclave is that the process does not dull and corrode or rust carbon steel instruments and after the work cycle is ended instruments are dry and immediately available for use. Besides the disadvantage of chemical odour in a poorly ventilated room its major drawback is its dependence on a continuous supply of the chemical agent.

**Dry heat sterilization**

This method has the lowest cost and does not corrode and dull instruments if the instruments are completely dry before being placed in the dry heat chamber. The disadvantages on the other hand are considerable. Since proteins of microorganisms do not denaturate so easily in dry air as they do in moist air (steam), dry heat sterilizes much less efficiently than steam. Moreover dry air is not as efficient a heat conductor as steam at the same temperature and consequently a much higher temperature is required for sterilization. It also requires long exposure times. Because high temperatures are needed, the heat up time and cool down time are long, resulting in long total working cycle.

Table 2 depicts appropriate exposure times and depending on the type of sterilizer, estimated working cycle at different temperatures.

Since circulation and penetration of dry hot air is slow, particularly in the centre of an instrument pack, a fan is needed to ensure a forced flow of hot air within all corners and entrapped air bells in the dry heat chamber. Since the working cycle is long it disrupts a smooth flow of instrument recirculation. Because of that drawback, a common misuse of this apparatus can occur when the oven is opened and an instrument is quickly removed

Table 2. Temperature, exposure time and overall working cycle time in dry heat sterilizer

| Temperature (°C) | Exposure time (min) | Total working cycle time (min) |
|---|---|---|
| 160 | 60 | 120 |
| 170 | 20 | 60 |
| 180 | 10 | 50 |

during the timed cycle. This interrupts the cycle and the sterilization programme should be repeated entirely. Therefore dry heat sterilizers should have a time lock on the door to prevent misuse. The shelves inside must be perforated and instruments should not be tightly packed.

The glass bead sterilizer for small endodontic items is a specialized variation of the dry heat principle. Conduction of the heat in this apparatus does not occur by circulation of the air but by direct contact through the glass beads which is much more efficient and hence the exposure time is shorter.

## Boiling water

Boiling of instruments in a water bath is widely practised in Tanzania but it can not be considered a reliable method to avoid cross-infection in medical surgery since spores of microorganisms can survive and may cause post surgical infections. In dentistry however spores do not pose a real threat (excluding extensive oral surgery) since the oral cavity harbours millions of microorganisms including now and then tetanus spores. Disinfection in a boiling water bath in dentistry aims to kill all non-sporing pathogenic microorganisms on instruments to prevent the transfer of such microorganisms from one patient to another. However it must be realised that boiling water disinfection in a water bath is actually an unacceptable compromise if one is aware of the conditions in Tanzania. Firstly most clinics are not located at sea level and consequently the temperature of boiling water does not reach 100°C. Table 3 shows temperatures of boiling water at various altitudes. In Lushoto and Mbeya for instance, boiling water reaches only 94°C. It has been noticed that many water bathes for disinfection of dental instruments operate with hot water but not with boiling water, so temperatures are even lower (5,6). Secondly, because of the continuous lack of sufficient supplies of instruments the boiling water bath method is often misused. It is opened at any time to remove instruments for use which have not yet been adequately exposed to the disinfection procedure (at least 20 min at 100°C).

Table 3. Temperature of boiling water and altitude

| Altitude (feet) | Temperature (°C) boiling water | Location in Tanzania (feet) |
|---|---|---|
| Sea level | 100 | Coastal region and islands |
| 1500 | 98.5 | Morogoro and Kilosa |
| 2000 | 98 | Kigoma |
| 3000 | 97 | Moshi |
| 4000 | 96 | Dodoma, Tabora, Lake Victoria |
| 5000 | 95 | Arusha, Iringa |
| 6000 | 94 | Lushoto, Mbeya |

## Recommendation

Each dental clinic should be equipped with an autoclave/pressure cooker. The Centers for Disease Control in the USA has suggested weekly monitoring of dental sterilizers with biological test strips (commercially available spores of Bacillus species). The test strips should be placed in the centre of the instrument pack, where sterilization is most difficult to achieve.

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