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Evaluation of the Effectiveness of Various Methods of Instrument Disinfection in Cosmetology

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Abstract

The history of disinfection and sterilization dates back to ancient times. Hippocrates' writings already described methods for treating wounds using fire and vinegar, which can be considered the first attempts to combat infection. In the Middle Ages, the spread of infectious diseases such as the plague contributed to the development of ideas about the need for disinfection. However, a scientific approach to disinfection emerged much later, in the 19th century, with the work of Louis Pasteur and Joseph Lister. It was Lister who first introduced antiseptic methods into medical practice, using carbolic acid to treat instruments and surgeons' hands.

With the advancement of microbiology, it became clear that instruments could carry pathogenic microorganisms. This discovery led to the widespread adoption of various disinfection and sterilization methods, which are now an integral part of not only medicine but also cosmetology. Instrument processing methods are particularly important in modern cosmetology practice, as these procedures often involve breaking the skin and risking infection.

The relevance of this study stems from the need to ensure the safety of clients and staff in cosmetology clinics. The growing number of cosmetology procedures and the expansion of services require strict adherence to sanitary and epidemiological standards and the use of effective disinfection methods.

The aim of this work is to evaluate the effectiveness of various methods of disinfection of instruments used in cosmetology, as well as to identify their advantages and limitations.

Scientific Novelty. The scientific novelty of this study lies in its comprehensive assessment of the effectiveness of modern instrument disinfection methods in cosmetology, taking into account the specifics of the industry. The study systematizes and compares physical, chemical, and combined disinfection methods based on their practical applicability in cosmetology settings. Particular attention is paid to the analysis of the combined use of ultrasonic cleaning and chemical disinfection as a method for improving the quality of disinfection of complex instruments.

The need for a multi-stage approach to disinfection, which minimizes microbial contamination to improve the quality and safety of the procedures performed, is also justified.

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	Purpose of the Study. The purpose of the study is to comprehensively evaluate the effectiveness of various instrument disinfection methods used in cosmetology, with the subsequent identification of the most reliable and safe treatment methods that reduce the risk of infection transmission and comply with sanitary and epidemiological requirements.

Keywords: Disinfection, sterilization, cosmetology, instruments, autoclaving, dry heat treatment, chemical disinfection, ultrasonic cleaning, ultraviolet radiation, microbial contamination, safety of procedures, sanitary standards, antiseptics, combined processing methods

Introduction

The history of disinfection and sterilization dates back to ancient times. Hippocrates' writings already described methods for treating wounds using fire and vinegar, which can be considered the first attempts to combat infection. In the Middle Ages, the spread of infectious diseases such as the plague contributed to the development of ideas about the need for disinfection. However, a scientific approach to disinfection emerged much later, in the 19th century, with the work of Louis Pasteur and Joseph Lister. It was Lister who first introduced antiseptic methods into medical practice, using carbolic acid to treat instruments and surgeons' hands.

With the advancement of microbiology, it became clear that instruments could carry pathogenic microorganisms. This discovery led to the widespread adoption of various disinfection and sterilization methods, which are now an integral part of not only medicine but also cosmetology. Instrument processing methods are particularly important in modern cosmetology practice, as these procedures often involve breaking the skin and risking infection.

Using proper cleaning and disinfection techniques is an integral part of ensuring cleanroom compliance. Disinfection is a procedure aimed at reducing the number of vegetative microorganisms by inactivating or destroying them. Removing bacterial and fungal spores is a more complex task. Specialized sporicidal agents are required for their removal. Disinfectants vary in their spectrum of activity, mechanism of action, and effectiveness. Several types of disinfectants must be used for cleaning cleanrooms. The requirement to use at least two disinfectants with different mechanisms of action is also enshrined in European GMP requirements.

Even if a disinfectant has successfully passed laboratory efficacy testing, this does not mean it will perform equally well in cleanrooms [1]. For example, during laboratory studies, it is difficult to account for factors such as air exchange rate. Air exchange rate determines exposure time, which in turn affects the effectiveness of the disinfectant, as its effect on microorganisms ceases after drying. This is especially important for sporicidal agents, as the destruction of spores requires a relatively long exposure time. Furthermore, each cleanroom complex has its own unique microflora. This is determined by the cleaning regimen, the personnel working there, the quality of the water supply, and other factors.

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Classification of disinfection methods

Disinfection methods can be divided into several main groups depending on the mechanism of action on microorganisms. These include physical, chemical, and combined methods. It is known that gram-positive bacteria are easier to destroy than gram-negative ones, and bacteria are less resistant than fungi. Bacteria that form endospores are the most resistant [2]. Therefore, before selecting disinfectants, it is necessary to carry out a set of measures to determine the species composition of the microflora of cleanrooms in which these agents are planned to be used. Thus, an assessment of the effectiveness of disinfectants, carried out directly in cleanrooms, allows us to supplement the results of laboratory studies.

Physical methods include high temperatures, ultraviolet radiation, and ultrasound. Chemical methods rely on the use of disinfectant solutions containing active ingredients. Combination methods combine elements of different approaches, such as the use of ultrasound in conjunction with chemicals.

There are various methods for removing air from the steam chamber, two of which are used in modern medical sterilizers: gravity and forevacuum. Gravity air removal involves removing air, which is heavier than the steam entering through a purge valve at the bottom of the sterilizer. The steam gradually fills the chamber, replacing the air.

In forevacuum sterilizers, air is removed by repeated cyclical evacuation of air from the sterilization chamber. Saturated steam is introduced into the chamber, and the steam-air mixture is evacuated. This evacuation cycle is repeated three to nine times (depending on the type of sterilizer) until all air is removed from the chamber, porous loads, and items containing voids. The steam-air mixture is evacuated using either a forevacuum pump or an injector [2].

Each of these groups has its own characteristics that determine their use in cosmetology practice.

Table 1 - Comparative characteristics of methods for disinfecting instruments in cosmetology

Disinfection method	Characteristics of effectiveness and limitations
Heat treatment	High efficiency, complete destruction of microorganisms, requires equipment and temperature control
Chemical disinfection	Availability and ease of use, effectiveness depending on concentration and exposure time
Ultrasonic cleaning	Removing contaminants from hard-to-reach surfaces is not a stand-alone sterilization
Ultraviolet radiation	Suitable for surface treatment, limited depth of action
Combined methods	Maximum efficiency through a combination of stages requires adherence to processing protocols

Thermal disinfection methods. Thermal treatment is one of the most reliable methods for killing microorganisms. Dry-heat ovens and autoclaves are widely used in cosmetology.

Dry-heat sterilization is carried out at temperatures between 160 and 180 degrees Celsius for a specified time. This method is effective against bacteria, viruses, and fungi [3]. However, it requires strict adherence to temperature and exposure time. A disadvantage is the lengthy process and the potential for damage to some instruments.

Autoclaving involves the use of saturated steam under pressure. This method is considered the gold standard of sterilization, as it ensures the complete destruction of all forms of microorganisms, including spores. However, autoclaves require regular maintenance and monitoring of operating parameters.

Research shows that thermal methods have a high degree of efficiency, reaching almost one hundred percent when all processing conditions are met.

Chemical disinfection methods. Chemical disinfection is the most common method in cosmetology due to its availability and ease of use. Solutions based on alcohols, aldehydes, chlorine-containing compounds, and quaternary ammonium compounds are used as disinfectants [4].

Alcohols such as ethanol and isopropanol are effective against most bacteria and viruses. They act quickly but do not kill spores and have a limited exposure time.

Aldehydes, such as glutaraldehyde, have a broad spectrum of activity and can be used for high-level disinfection. However, they are toxic and require safety precautions.

Chlorine-containing agents are effective against a wide range of microorganisms, but can cause corrosion of metal instruments.

Quaternary ammonium compounds are used to treat surfaces and instruments with a low risk of contamination. They have a bactericidal effect, but are less effective against viruses and fungi.

The effectiveness of chemical methods depends on the concentration of the solution, the exposure time and the correct preparation of instruments before treatment [5].

Ultrasonic cleaning. Ultrasonic treatment is used as an auxiliary method for cleaning instruments. It relies on the phenomenon of cavitation, which creates microscopic bubbles that break down contaminants on the instrument's surface.

This method does not provide disinfection on its own, but it significantly improves the effectiveness of subsequent treatment. It is especially useful for complex instruments where mechanical cleaning is difficult.

Research shows that the use of ultrasound in combination with chemical agents can reduce the microbial load to a minimum level [6].

Ultraviolet radiation. Ultraviolet radiation is used to disinfect air and surfaces. In cosmetology, ultraviolet cabinets are used for storing instruments.

However, it's important to note that ultraviolet light does not provide complete sterilization, as its effect is limited to the surface layers. Furthermore, its effectiveness is reduced by contamination. Therefore, ultraviolet radiation should be considered as a complementary method rather than a primary method of disinfection.

Combined methods. The most effective approach is a combination of different methods. For example, preliminary mechanical cleaning, followed by ultrasonic treatment, followed by chemical disinfection and subsequent sterilization in an autoclave [7].
This comprehensive approach ensures maximum safety and reduces the risk of infection transmission.

Factors Affecting Disinfection Effectiveness. Disinfection effectiveness depends on a number of factors. These include the degree of contamination of instruments, the type of microorganisms, the concentration of the disinfectant, the exposure time, and the temperature.
Proper pre-cleaning is especially important. The presence of organic contaminants significantly reduces the effectiveness of disinfectants.
It is also important to follow the instructions for use and regularly monitor the quality of the treatment.

Table 2 - Factors affecting the effectiveness of instrument disinfection

Factor	Impact on efficiency
Degree of organic pollution	Reduces the effectiveness of disinfectants if pre-cleaning is insufficient
Solution concentration	Determines the strength of antimicrobial action and the rate of inactivation of microorganisms
Exposure time	The longer the exposure, the higher the level of destruction of microorganisms
Temperature conditions	Increases the efficiency of most chemical and physical methods
Type of microorganisms	Spores and viruses have varying resistance to treatment

Comparative analysis of methods. A comparison of various methods shows that thermal methods provide the highest level of safety, but require specialized equipment [8]. Chemical methods are more accessible, but their effectiveness may vary.
Ultrasonic cleaning and ultraviolet radiation play a supporting role and cannot replace the main methods.
A combined approach is the optimal solution, taking into account the advantages of each method.

Conclusion
Instrument disinfection in cosmetology is a critical element in ensuring the safety of procedures [9]. A variety of methods allows for the selection of the optimal approach depending on the conditions and type of instrument.
Thermal methods, such as autoclaving, are the most effective, ensuring complete destruction of microorganisms. Chemical methods remain popular due to their availability, but require strict adherence to the conditions of use [10].

The use of auxiliary methods such as ultrasound and ultraviolet light increases the overall effectiveness of treatment, but cannot replace the main methods of disinfection.

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