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Hand Hygiene in Dental Health Care

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Abstract: *The article provides basic information on the necessity to follow methodological instructions concerning hand hygiene in a dental health-care. The dental health-care settings are an environment where disease transmission occurs easily. Prevention of cross infection is therefore a crucial aspect of dental practice. PubMed on-line database, Guidelines of the Centers for Disease Control Atlanta and World Health Organization were used. A historical summary describes the most important landmarks in the development of specialized recommendations related to the above issue. Having provided the basic information about the hand microflora we continue with an overview of recommended and the most widely spread antiseptics used for hand hygiene. Furthermore, we describe current legislation of the Czech Republic concerning the present problem in detail. In conclusion, attention is drawn to the possible health impairment to hand skin related to the use of the listed antiseptics. This factor is specified as one of the many that may participate in the low compliance of practising hand hygiene in health care.*

Keywords: *hand microflora, alcohol-based antiseptics, compliance*

I. Introduction

As hands are the most important tool of a dentist, taking care of them in order to protect them from infection is of utmost importance. Their microbial contamination is caused by any contact or aerosol when treating a patient [1]. It is, therefore, necessary to observe effective methods of personal hygiene and hand maintenance to minimize the risks of transferring an infectious agent. There are numerous studies highlighting the spots neglected when sanitizing disinfecting hands. Current Czech legislation specifies when the health staff is obliged to sanitize and disinfect hands [2].

Miscellaneous studies of the past 20 years verify that at least one third of hospital-acquired infections could be avoided. A dental surgery is one of the places where an infectious agent can be transferred onto a patient and cause a hospital-acquired infection. The number of hospital-acquired infections resulting from the treatment of teeth is not available. It is nevertheless obvious that hand hygiene could play one of the key roles in this problem. The international hygienic standards for hospitals and dental surgeries are, therefore, becoming more restrictive: e.g. facilitiesare required to have touchless technical equipment for hand sanitation and disinfection.

In the Czech Republic, the Journal of the Ministry of Health of the Czech Republic published in 2012 the Methodological Measure: Hand Hygiene in Health Care [3].

II. History

In 1847, Ignaz Semmelweis, an Austrian gynaecologist born in Hungary, published a work on the necessity of sanitizing and disinfecting hands before examining and delivering children. To sanitize hands, he used a solution of chlorinated lime. This was the first important preventive measure concerning the transfer of infectious agent through contact.

In the past 40 years, several clinical controlled studies have been conducted among nurses, demonstrating that due procedures of hand sanitation and disinfection decrease the amount of temporary or permanent microflora on hands and significantly contribute to the reduction in the transfer of infectious agents by medical staff [4]. In 1961 an education film was made in the USA to inform medical staff about the proper method of hand sanitation. At that time, it was recommended to wash hands with soap and water for the duration of 1-2 minutes [5].

The year 1980 is considered to mark a milestone in the development of the concept of hand hygiene in health care facilities. The first national guidelines on hand hygiene were published and implemented in the USA, Canada, and some of the European countries. Within the last twenty years the hand hygiene guidelines have recorded major changes. In May 1993, the Centers for Disease Control and Prevention (CDC) in Atlanta

issued a guideline for practical controls of microbial contamination in dental surgeries. The chapter titled "Barrier Techniques" specifies the method of hand sanitation and the use of gloves when performing various types of procedures. Hands are recommended to be washed with soap and water (to remove the transient microflora) before and after standard treatment of individual patients. In the case of surgical procedures, surgical sanitation and sterile gloves are to be used [6]. Between 1995 and 1996 the CDC, Atlanta, elaborated guidelines for hand hygiene using alcohol-based antiseptics. These changes were mainly connected to the spread of multi-antibiotic resistant strains: the methicillin resistant *Staphylococcus aureus* (MRSA) and vancomycin resistant enterococci (VRE). The final version of the above recommendations was published in 2002 [4].

In Central European countries the use of alcohol-based antiseptics was a method of choice [4], and yet in some of the countries the above antiseptics were designated only for selected departments [7].

The last CDC guideline to date concerning prevention of infection in dental surgeries was published in December 2003. It includes a chapter dealing with hand sanitation and disinfection [8].

In 2006, the WHO issued a comprehensive publication "WHO Guidelines on Hand Hygiene in Health Care (Advanced Draft)", examining in detail both alcohol-based antiseptics and antiseptics based on other chemicals, used for hand disinfection. It also discusses their negative effect on the skin of the hands, e.g. allergy [9]. The last WHO publication on hand hygiene dates to 2009 [10]. In 2008, Klevens and his team published an article addressing prevention of the transfer and spreading of MRSA in dental surgeries [11].

III. Microflora of the Skin of the Hands

In 1938 Price observed that microorganisms found on the skin of the hands could be divided into two groups: resident microflora and transient microflora [12].

The skin of human hands is permanently inhabited by resident microflora, composed of microorganisms found in the deeper layers of epidermis, in the outlets of sebaceous sweat glands, and around nails in constant ratios. The resident microflora consists, above all, of coagulase-negative staphylococci, with the *Staphylococcus epidermidis* strain as the dominant type and *Staphylococcus aureus* also possible. On a smaller scale there could be non-pathogenic corynebacteria, and from fungi e.g. *Pityrosporum (Malassezia)* spp. [13, 14]. It is not very likely for the resident microflora to cause an infection. As an exception, it could become an infection agent at sterile locations of human organism, in the eyes or where the skin is broken [15].

The other group involves transient microflora, which colonizes the surface of the skin. Its quantity and the number of the present microorganisms reflect the microbial load of the environment and the character of the performed work. Mostly it does not tend to be permanently present, as the number of present microorganisms can be reduced even with mechanical hand sanitation [14]. Contaminated hands may transfer microorganisms directly (the medical staff's hands touch the skin or mucous membrane of the patient) or indirectly (there must be a suitable vehicle on which the infectious agent survives and is subsequently transferred onto a patient). Transient microflora is a frequent cause of hospital-acquired infections.

The total number of bacteria on the hands of the medical staff is indicated to fall within 3.9×10^4 to 4.6×10^6 CFU/cm^2 [14]. The hands of some of the medical staff may also be colonized by pathogenic microorganisms, e.g. by the Staphylococcus aureus strain, gram-negative bacteria or yeast [16].

IV. Means Used for Hand Hygiene

The qualities of water collected from water mains and designated for hand sanitation must comply with drinking water, whose parameters for the Czech Republic are declared in Decree 252/2004 Coll., Appendix 1 and 2, and in the subsequent amendments. § 3 article. Drinking water and hot water must not contain microorganisms, parasites, and substances of any kind in the number or concentration that could imperil public health [17]. The water temperature ranging from 5°C to 50°C used for hand sanitation does not affect the reduction of various types of microorganisms of the residual or transient microflora [18].

Detergents (standard soaps) contain tensides only, which decrease the surface tension of their solvents. When applied to the hand skin, they may form a film under which some microorganisms might survive. Washing hands with standard soaps can lead to a paradox - the number of microorganisms on the skin increases [19, 20, 21]. Detergents have no disinfectant effect, nor do they reduce the amount of bacteria and viruses sufficiently. Utmost caution must be paid when a standard soap (liquid, solid) is contaminated by gram-negative bacteria, e.g. Pseudomonas aeruginosa, Serratia spp. [22]. The liquid soap dispenser should be equipped with touchless control; due to the above possibility of contaminated content of the dispenser it is necessary to disinfect the entire dispenser prior to replacing the soap. Soap may be prevented from becoming contaminated only when using soap with a disinfectant component [1].

Drying of hands is an absolutely necessary step of the whole process of hand hygiene. Hand drying with disposable paper towels stored in a dispenser with the bottom disposing system is considered the best procedure. Another option is to dry hands with hot air from an electrical dryer. With this procedure, hand drying takes more time and the hot air may have an adverse effect on the skin. Another negative aspect is the possible

formation of aerosol containing microorganisms, where the vehicle is a wet biofilm on wet hands [23].

Hand disinfection must be carried out in accordance with the current legislation. Hand disinfection is the most fundamental and effective measure of discontinuing the channel for transferring and spreading infectious agents. The skin antiseptic must not sensibilize, irritate or excessively degrease the skin. Launching of new antiseptics must be carried out in accordance with the current legislation of the Czech Republic [24]. The spectrum of the antimicrobial activity of hand antiseptics should be based on data about transient microflora on the hands of medical staff and its role in the established hospital-acquired infections. The minimum spectrum of the antimicrobial activity of antiseptics includes the bactericide, fungicide (affecting yeast) and virucide (affecting coated viruses) activity. The requirement for a virucide activity affecting coated viruses is grounded on the risk of contaminating hands with biological material that could contain VHC or HIV agents. It is possible to be vaccinated against VHA and VHB [25].

V. Antiseptics Reducing the Number of Microorganisms on Hands

Alcohols

The majority of alcohol-based antiseptics contain ethanol, isopropanol or *n*-propanol or a combination of two of the above. The antimicrobial activity of the alcohols ensues from their ability to denaturate proteins. Alcohol solutions containing 60-80 % of alcohol are the most efficient; with a higher concentration the efficiency drops. This paradox is connected to the fact that it is not easier for proteins to denaturation when there is no water [26].

In vitro, alcohols have an excellent germicide effect on gram-positive and gram-negative bacteria including multi-resistant hospital-acquired strains (MRSA, VRE) and Mycobacterium tuberculosis. They have practically zero effect on bacterial spores and protozoan oocysts and very little effect on non-coated viruses. The hepatitis B virus and probably also the hepatitis C virus are killed with 60-70% alcohol solution [27].

Ethanol was recommended for hand antisepsis for the first time ever in 1888. Its antimicrobial effects are very well known [28]. It demonstrates a strong immediate bactericide activity at as little as 30 % concentration. The optimal bactericide activity on the *Staphylococcus aureus*, *Enterococcus faecium* and Pseudomonas aeruginosa strains it exerts when at a 80% concentration [29]. In addition, ethanol has a good anti-tuberculocidal activity. The spectrum of virucidal activity depends on the ethanol concentration. For example, 95% ethanol solution has a better virucidal activity than 60-80 % concentration, especially against non-coated viruses [30]. In 1994, the organization Food and Drug Administration (FDA) recommended a 60-95% ethanol as a generally active substance for hand antisepsis or as a part of preparations designed for hand hygiene of medical staff [31].

Ethanol has no sporicidal activity. If contaminated by spores, these must be removed by filtration only.
The antimicrobial activity of isopropanol and *n*-propanol was demonstrated for the first time as early as in 1904 [32]. They have a similar bactericidal activity and are used at 50-60% concentration. They dry the skin out less than ethanol.

The efficiency of antiseptics designated for hand hygiene depends on many factors, e.g. the type of alcohol used, its concentration, applied volume, the contact time, and whether the hands are dry at the time of applying the antiseptic. A small quantity (0.2-0.5 ml) of applied alcohol has no greater effect than washing hands with water and standard soap [33].

The antiseptics for hand hygiene are manufactured as low viscosity solutions, gels, and lotions. Frequent use of these antiseptics may dry out the skin of the hands. This may be reduced or eliminated by adding 1-3 % glycerol or other substances that decrease the drying out of skin [34]. Allergic contact dermatitis or contact urticaria recorded following the exposure to an alcohol-based antiseptic are rare. The allergic reaction is probably related to the chemical impurities that may be present in the alcohol. Some other substances present, e.g. stearyl or isostearyl alcohol, benzyl alcohol and others may also be responsible for the allergic reactions [35, 36].

Summary: ethanol (60-85%), isopropanol (60-80%) and *n*-propanol (60-80%) have a very good activity against vegetative bacteria, mycobacteria, yeast, dermatophytes, and coated viruses. Ethanol is more effective against non-coated viruses than isopropanol and *n*-propanol. None of them has demonstrated acquired resistance.

Chlorhexidine

Digluconate or diacetate of 1.6-bis (4-chloro-phenyl biguanide)-hexane was developed in England at the beginning of the 1950s and introduced in the USA in the 1970s. Its immediate antimicrobial activity is slower compared to alcohols and depends on its concentration. The bactericide effect applies, above all, to gram-positive bacteria, while its effect on gram-negative bacteria is lesser. Likewise, the fungicide activity is lower, the tuberculocidal effect minimum, and the sporicide zero.

The virucide activity against most coated viruses is good (HIV, cytomegalovirus, influenza virus, RSV and the herpes simplex virus) [37]. Organics, including blood, do not reduce its efficiency.

Chlorhexidine has a substantial residual effect. Adding it in low concentrations (0.5-1 %) to alcohol-based antiseptics significantly increases their residual effect [38].

In the event of eye contact, preparations with chlorhexidine concentration 1% or higher may cause conjunctivitis or serious damage to the cornea. Skin irritation also depends on the chlorhexidine concentration. If frequently used, antiseptics containing 4% chlorhexidine induce dermatitis [39].

Occasionally attention is drawn to hospital-acquired infections emerging in connection to a contaminated solution of chlorhexidine; *Serratia marcescens* is the most frequently cultivated bacterium [40]. Resistance to chlorhexidine has been registered, in particular with gram-negative bacteria [41]. Chlorhexidine is the main active component of various antiseptics used for hand hygiene, e.g. Prosavon, Spitaderm, Desmanol.

Triclosan (2,4,4-trichloro-2´hydroxydiphenyl ether) is an organic compound of faint phenolic odour. It contains ether and phenol functional groups. In water it is nearly insoluble, but in most organic solvents and alcohol solutions it dissolves easily.

It has been used in disinfectant soaps for a long time (0.15-0.30%); bathing in a 2% triclosan solution is recommended to decolonize patients with MRSA [42]. *Pseudomonas aeruginosa* is innately resistant to triclosan [43]. If triclosan penetrates into surface waters, it may generate dioxins [44].

VI. Hand Hygiene in Health Care

According to the Journal of the Ministry of Health of the Czech Republic "Methodological Measure: Hand Hygiene in Health Care", we distinguish [3]:

***1. Mechanical hand sanitation as part of personal hygiene* –** mechanical removal of impurities and partially also of transient microflora from the skin of the hands. It is performed before and after standard contact with patients, after removing gloves, etc. Basic tools involve a liquid detergent from a dispenser, bath soap, running drinking water, and disposable towels.

Procedure: the detergent is applied on wet hands and rubbed well over. With a small amount of water it is developed into lather and the hands are washed for 30 seconds. Afterwards they are rinsed with running drinking water and dried out with a disposable towel.

***2. Mechanical hand sanitation before surgical disinfection of hands* –** mechanical removal of impurities and partially also the transient microflora from the skin of the hands and forearms before the surgical disinfection. It is carried out before the start of the surgical programme.

Basic tools involve a liquid detergent from a dispenser, running hot water from a touchless water faucet, a disposable or sterile nail brush, and disposable towels (masks) stored in a suitable feeder.

Procedure: is identical to the procedure of mechanical hand sanitation for 1 minute, enhanced with mechanical sanitation of the forearms. In the case of visible impurities, use a nail brush for nails, nail ridges, and fingertips.

3. ***Surgical hand disinfection reduces* -** the amount of transient and resident microflora on the skin of the hands and forearms.

Carried out: before starting the surgical programme, in between individual procedures, and when the glove integrity is violated or the gloves are replaced during the procedure. The only tool is a liquid alcohol-based disinfectant designated for surgical hand disinfection, supplied from a touchless dispenser.

Procedure: about 10 ml of alcohol-based disinfectant are rubbed into the dry skin of the hands and forearms for 3-5 minutes (from the fingertips towards the elbows, from the fingertips to the mid-forearms, and from the fingertips to the wrists) until completely dried. The hands must be wet for the entire duration of the exposure; no rinsing or wiping. After the surgical programme, the hands are washed with hot water and soap and dried.

***4. Hygienic hand disinfection* reduces-** the amount of the transient microflora from the hand skin with a view to discontinuing the channel for transferring microorganisms. It is carried out as part of: the barrier treatment technique and hygienic filter, after accidental contamination of hands with biological material, and in the case of tearing the gloves during the procedure.

The only tool is an alcohol-based disinfectant designated for hygienic hand disinfection. This type is to be used exclusively upon the emergence of the methicillin- resistant *Staphylococcus aureus* strain. Alcohol-based disinfectants may be replaced by other disinfectants designated for hand disinfection.

Procedure: about 3 ml of alcohol-based disinfectant are rubbed into the dry skin of the hands for 30–60 seconds until completely dry. No rinsing or drying of the hands.

5. Hygienic sanitation of the hands removes impurities and reduces the amount of transient microflora on the hand skin with disinfecting detergents. It is more efficient than mechanical hand sanitation but less efficient than hygienic hand disinfection. It is carried out when preparing and distributing meals and performing personal

hygiene. Not suitable for routine use in health care.
Requirements for alcohol-based disinfectants:

- delivered in the original packaging,
- possibility of an immediate use of undiluted preparation, rapid effect,
- containing a moisturizer preventing the skin from drying out,
- dosed with dispensers (if the dispenser is used repeatedly, it is necessary to rinse and wash, disinfect or sterilize the dispenser every time the contents are replaced; the same procedure must be followed with liquid detergent dispensers).

The use of gloves

There are two types of gloves used by medical staff:

- Latex, labelled NRL = Natural Rubber Latex, i.e. "This product contains natural rubber latex which may cause allergic reactions". These involve immediate hypersensitivity (type I hypersensitivity, pursuant to Coombs and Gell). Immunoglobulin E (IgE) is the intermediary of a hypersensitive reaction to NRL. The reaction is caused by proteins and polypeptides discharged from the final products. Peptides of a small molecule weight play a decisive role.
- Latex free. It is a synthetic material (vinyl, nitrile, and neoprene).

The gloves serve as occupational protective equipment. They provide a mechanical barrier that:

- lowers the risk of transferring the microflora from the patient to the staff and vice versa,
- partially protects the hand skin from the aggressive effects of disinfectants and other harmful substances, and
- selection of gloves depends on the type of the expected activities.

Procedure for glove use

For procedures containing a risk of an unplanned parenteral exposure or a planned parenteral exposure into the organism only disposable sterile gloves may be used, while aseptic procedures must be observed during the manipulation. After removing the gloves, the hands must be washed; in the event of tearing a glove during the procedure, the hands must be hygienically disinfected and subsequently mechanically sanitized. In the case of continuing the procedure, the hands must be hygienically disinfected again.

Non-sterile disposable gloves may be used to examine physiologically non-sterile cavities (for procedures excluding the risk of violating the integrity of the mucous membrane).

When handling the biological material of patients, cleaning, and working with other harmful substances, the protective gloves must effectively protect against the used harmful substance.
Used gloves must be disposed as specific medical waste.

VII. Skin Reaction Related to Hand Hygiene in Health Care

The antiseptics used for hand hygiene cause the denaturation of proteins in the stratum corneum, changes in intercellular lipids, a drop in the cohesion of corneocytes, and a decrease in the water binding capacity in the stratum corneum. Frequent sanitation leads to a severe drop in the surface lipids, resulting in a deep effect of the detergents in the surface layers of the skin. The damaged skin records changes in the skin microflora; there is a higher incidence of colonization by staphylococci and gram-negative bacteria. The alcohol effect on lipids is inversely proportional to their concentration; ethanol has lower irritation qualities than n-propanol and isopropanol. There are two main types of skin reactions related to hand hygiene in health care:

The first and more common, including the symptoms, which range from mild to severe, are termed the irritant contact dermatitis. It usually occurs in connection with the use of iodophor antiseptics, but may also involve chlorhexidine or triclosan. Alcohol-based antiseptics irritate the least.
The other type is an allergic reaction to antiseptics applied to hands. It occurs as a delayed type of reaction (allergic contact dermatitis) or less frequently as an immediate type of reaction (contact urticaria). Allergic reactions to antiseptics are related to their absorption into the skin. Allergic contact dermatitis appearing after the use of alcohol-based antiseptics is very rare. The allergic reaction is probably related to the chemical impurities that may be present in the alcohol. Some other substances present, e.g. stearyl or isostearyl alcohol, benzyl alcohol and others may also be responsible for the allergic reactions [35].

VIII. Compliance with Hand Hygiene Applied in Health Care

It is a well-known fact that the performance and observance of hand hygiene in health care is poor. The compliance level ranges between 16 and 81 %, with the average value of 40 % [45]. There are many factors listed as a reason for the insufficient hand hygiene in health care, such as lack of time during the procedures,

damage to the skin connected to the use of antiseptics, etc.

In the past 10 years, the Medline baseline has recorded only one original article on the evaluation of the implementation of hand hygiene in general dental practitioners. The questionnaire survey took place between October and November 2006. Out of the total sample of dentists, 71 % wash their hands with standard soap and water while 22 % wash their hands with soap and water and use alcohol-based antiseptics. The study, conducted in the USA for the first time, concludes saying: it is absolutely necessary to hold regular training of dental practitioners in the execution of hand hygiene and inform them about the new CDC recommendations [46].
We believe that a similar study in the Czech Republic would provide a volume of interesting information.

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