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SAMPLING OF MICRO AND NANO PARTICLES FROM AEROSOLS GENERATED DURING DENTAL INTERVENTIONS

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Abstract: *Dentists and dental team members are exposed to an increased risk of large amounts of aerosols in the working atmosphere during clinical dental procedures. The analysis of the part of the aerosol that includes the finest particles of micro and nano dimensions is a starting point for understanding the relationship between exposure to aerosols and negative effects on the health of dentists. The paper presents the methodology and experimental realization of clinical sampling of micro and nano particles, from the aerosol generated during dental interventions, using a personal sampler.*
Key words: *sampling, micro and nano particles, aerosol, dental interventions*

Uzorkovanje mikro i nano čestica iz aerosola generisanog u okviru dentalnih intervencija. *Stomatolozi i stomatološko osoblje su izloženi povećanom riziku od velike količine aeorosola u radnoj atmosferi u toku kliničkih stomatoloških procedura. Analiza dela aerosola koji obuhvata najfinije čestice mikro i nano dimenzija, predstavlja polaznu tačku za razumevanje odnosa između izloženosti aerosolima i negativnih uticaja na zdravlje stomatologa. U radu je predstavljena metodologija i eksperimentalna realizacija kliničkog uzorkovanja čestica mikro i nano dimenzija, iz aerosola koji se generiše prilikom stomatoloških intervencija, primenom personalnog uzorkivača.*
Ključne reči: *uzorkovanje, mikro i nano čestice, aerosol, dentalne intervencije*

1. INTRODUCTION

An aerosol can be defined as a "suspension of solid or liquid particles in a gas" that are up to 50 µm. In both phases, when it comes to the aerosol generated during dental interventions, various types of bacteria, viruses, organic particles of soft and hard tissues from the oral cavity and blood elements can be present [1]. The amount of contamination of the sprayed aerosol depends on many factors: the quality and composition of saliva, the presence or absence of local oral infection, dental plaque, as well as secretions in the upper respiratory tract, the presence or absence of blood which depends on the type of dental procedure, the ventilation of the room etc.

The increased risk of a large amount of aerosols in the working atmosphere during clinical dental procedures is largely contributed by dental work units that function according to the principle of the flow of water and air under pressure, through very narrow openings, with water stagnation and heating of the dental chair, which favors the formation of often highly contaminated environment. Toxic aerosols containing particles of toxic chemical elements and their compounds can cause poisoning or even death of living beings. When an aerosol contains biological particles such as viruses, bacteria, fungi, pollen, plant or animal remains, as well as fragments and products of these organisms, it is called a bioaerosol and represents a potential allergen and contaminant. Pathogenic microorganisms known to be transmitted via aerosols include various types of viruses and bacteria [1,2].

The analysis of the part of the aerosol that includes the finest particles of micro and nano dimensions, represents a starting point for understanding the relationship between exposure to aerosols and the negative effects on the health of dentists, who are exposed to various agents throughout their working hours, as a result of various interventions in the oral cavity. The interventions themselves, as well as the materials used, are linked to various diseases in the scientific and professional literature [3,4,5].

The International Organization for Standardization (ISO) as well as the European Committee for Standardization (CEN) defined three categories of particulate matter depending on the impact on human health [6]:

1) inhalation,
2) thoracic and
3) respiratory fraction of particulate matter.

The respiratory fraction includes the size of airborne particles that can penetrate beyond the terminal bronchioles into the gas exchange region of the lungs. Although the risk of exposure and health effects is greater the smaller the particles are, the limit value for particle fractions smaller than 2.5 microns does not exist. If we start from the fact that each surface tends to have different molecules adsorbed on it and that as long as the particles are much larger than 100 nm (0.1 µm) the number of adsorbed molecules increases slightly with decreasing particle size, but if particles smaller than 100 nm (0.1 µm) are present, the percentage of molecules on the surface increases exponentially, which is reflected in the increased chemical and biological activity of nano-sized particles [7]. So, it is very important to examine the respiratory fraction of particles, which present the danger of carrying other active particles with them, as well as bacteria and viruses.

This paper presents the methodology and experimental realization of clinical sampling of micro and nano particles from the aerosol generated during dental interventions.

2. MATERIALS AND METHODS

In order to examine the level of exposure to polluting substances, the measurements need to be carried out in the immediate vicinity of the breathing zone of the worker, in this case the dentist. If the dentist changes his position during work, representative samples should be taken in all representative positions he takes during work. These samples are the most important in the assessment of harm to health and simulate the amount of polluting substances that reach the dentist's lungs.

For the aforementioned reasons, the research is based on the application of a personal air sampler, which enables the collection of samples of contaminated aerosols (micro and nano levels) in the breathing zones of dentists, during various dental interventions.

Personal sampling simulates the collection of the fraction of powdery substances that would be inhaled by the dentist wearing the device itself. The method provides information on the amount of air sampled and allows further examination of pollutants in air mass/volume units. The share of particles that can penetrate the respiratory system in airborne dust is defined as "the whole class of particles, which, due to respiratory movements, can reach the bronchial or alveolar areas of the lungs and have the possibility of staying there". Due to the difficulty to simulate the physiological behavior of the respiratory tract, the determination of the fractions that can penetrate the respiratory system are performed in relation to conventional theoretical models.

2.1 Personal sampler EGO PLUS TT

The personal sampler used in this research is the EGO PLUS TT (Figure 1) with a display setting, a cyclone attachment and a filter made of a mixture of cellulose esters, with a pore size of 0.2 µm and a diameter of 25 mm. The speed of the air flow that the device sucks on the principle of the pump was 1.2 l/min at all locations, which is in accordance with the manufacturer's recommendation (Zambelli, Italy) when using the cyclone attachment for measurements of respiratory fractions of dust.

The EGO PLUS TT personal dust sampler determines 90% penetration of lung particles smaller than 2 µm in aerodynamic diameter. In order to perform sampling of fractions that can penetrate the respiratory system, the personal sampler is connected to a suitable two-phase sampler extension, which is intended for taking samples of particles whose aerodynamic diameter is less than 2 µm. The two-phase extension consists of a cyclone, which simulates a respiratory tract covered with bronchi, and a filter holder that has the ability to collect particles passing through the cyclone (Figure 1).

a)

b)

Fig. 1. Personal sampler EGO PLUS TT (a) with two-phase extension cyclone (b)

The air flow for this type of measurement is very low and in combination with filters made of a mixture of cellulose esters with small pores (0.2 µm) allows proper collection of submicron and nanoscopic particles. Such filters are suitable for testing the contamination of working environments, they are weight constant, hydrophilic and can be used at temperatures up to 125°C.

2.2 Sampling procedure

Sampling is realized by setting up a continuation of the personal sampler within the first zone, i.e. the cyclone attachment is positioned in the breathing zone of the dentist. The breathing zone includes the space around the dentist's face from which he takes air, and it is a general recommendation that it does not extend more than 30 cm from the mouth (Figure 2).

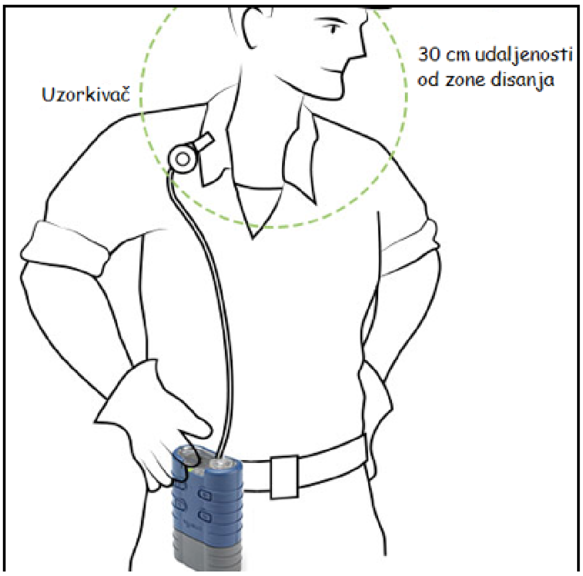

Fig. 2. Positioning of the extension of the personal sampler during sampling

The problem with sampling can be the very design of the cyclone attachment with a very small opening for air to penetrate to the filter, as well as the filter itself, which is extremely "dense" in structure. However, due to the planned analysis of the particles collected on the filter on a scanning electron microscope (SEM), which requires as little overlap of particles as possible for easier analysis, the sampling time is limited to up to 20 minutes.

Face masks have been shown to greatly reduce the risk of inhalation of aerosols by the dentist from the patient's airways, as well as aerosol dispersal by the therapist and exposure of the patient.

The particles are mostly concentrated in a diameter of 2 meters from the patient, where dentists and support staff can easily inhale them. Spraying aerosols does not have to involve the use of dental instruments, such as handpieces, handpieces, turbines or ultrasound machines, although due to working under air and water pressure they are certainly conducive to contamination, but the release of aerosol droplets can also occur during the conversation between the patient and the therapist when establishing a diagnosis. The distance between the therapist and the patient is extremely small, the scattering of particles with a diameter greater than 2 meters is also contributed by the processes of coughing and sneezing, and very often in order to facilitate communication with the patient, the therapist does not protect himself during the conversation, considering that there is a small possibility of infection until it starts on its own dental procedure. For these reasons, the use of surgical face masks in dentistry is very important to protect the dental staff from the patient's entry into the office, until the very end of the intervention, which also contributes to the protection of patients from possible contamination [8-15].

In accordance with the previous, the research was carried out both with and without (outside and inside) dentist's protective equipment, which allows obtaining a more realistic insight into the state of air contamination in the respiratory zone.

3. EXPERIMENTAL CLINICAL SAMPLING

An experimental clinical study of the exposure of dentists to aerosol particles was carried out in the Dentistry Clinic of Vojvodina. During the research, all epidemiological protection measures were observed in the form of the use of protective masks and gloves, both by dentists and auxiliary dental staff. The previously described EGO PLUS TT personal sampler was used for sampling.

Sampling of aerosol particles was carried out during routine dental interventions, which include:

- removal of amalgam fillings,
- removal of carious lesions and
- removal-correction of acrylate mobile prosthetic restorations.

The research was carried out on a total of 10 patients:

- in three patients the dental intervention included the removal of the amalgam filling,
- in five patients the dental intervention was the removal-correction of acrylate mobil prosthetic restorations and
- in two patients the dental intervention was the removal of carious lesions.

The sampling period was limited to 10 minutes, and protective surgical masks and N-95 masks were used during sampling. Before the start of sampling, trial testing of the sampler was done, as well as the setting of the sampler's operation for 10 minutes. Before each sampling, a new filter with a thickness of 0.2 mm is placed in the cyclone of the sampler, on which the sample is collected. The extension of the sampler is placed and fixed in the area of the therapist's left shoulder and positioned at the height between the therapist's nose and mouth.

Sampling of particles by removing the amalgam filling was carried out in the standing position of the dentist, with the assistance of auxiliary staff. N95 protective masks were used - one was placed on the sampler's cyclone and the other was applied to the dentist's face. For the removal of the amalgam filling, a diamond burr and a high-throughput implanted instrument KaVo E680L turbine were used.

Fig. 3. Particle sampling during amalgam filling removal

When sampling acrylate particles, as in the previous intervention, an N95 protective mask was used, which was placed on the sampler's cyclone, as well as on the dentist's face. A KaVo Expertmatic E10C handpiece with a carbide bur was used.

Sampling of aerosol particles by removing carious lesions was carried out using a surgical mask placed on the sampler's cyclone as well as on the dentist's face. Caries removal is mandatory using the KaVo E680L turbine and a diamond burr. After the completion of each of the 10 dental interventions, the protective mask was removed from the sampler's cyclone, the filter withthe aerosol sample was taken out and stored in a 50x50 mm Zipp bag (Figure 4).


Fig. 4. Aerosol sample filter

4. CONCLUSION

The paper presents the methodology of sampling micro and nano particles from aerosols that are generated during common dental interventions. The methodology was applied in a clinical study that included three types of dental interventions, on a total of ten patients. In previous research, the methodology has proven to be successful, and further research will, in one direction, be focused on the analysis of filters with collected samples on a scanning electron microscope (SEM). In this way, information about the morphology, texture and chemical composition of the sample will be obtained. The second direction of the continuation of the research will be focused on the inclusion of additional dental interventions, as well as new patients, all with the aim of obtaining a more representative sample. The results of the research will contribute to determining the intensity of the danger to the health of dentists and dental staff, due to the inhalation of aerosols that can potentially contain various pathogenic microorganisms, as well as heavy metal ions.

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