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Do exposures to aerosols pose a risk to dental professionals?

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Background	Dental care professionals are exposed to aerosols from the oral cavity of patients containing several pathogenic microorganisms. Bioaerosols generated during dental treatment are a potential hazard to dental staff, and there have been growing concerns about their role in transmission of various airborne infections and about reducing the risk of contamination.
Aims	To investigate qualitatively and quantitatively the bacterial and fungal aerosols before and during clinical sessions in two dental offices compared with controls.
Methods	An extra-oral evacuator system was used to measure bacterial and fungal aerosols. Macroscopic and microscopic analysis of bacterial species and fungal strains was performed and strains of bacteria and fungi were identified based on their metabolic properties using biochemical tests.
Results	Thirty-three bioaerosol samples were obtained. Quantitative and qualitative evaluation showed that during treatment, there is a significant increase in airborne concentration of bacteria and fungi. The microflora included mainly gram-positive organisms (*Staphylococcus epidermidis* and *Micrococcus* spp.), gram-positive rod-shaped bacteria and those creating endospores as well as non-porous bacteria and mould fungi (*Cladosporium* and *Penicillium*).
Conclusions	Exposure to the microorganisms identified is not a significant occupational hazard for dental care professionals; however, evidence-based prevention measures are recommended.
Key words	Bioaerosols; dental care professionals; health risk; indoor control; occupational hazard.

Introduction

Oral surgery is performed using a variety of hand tools including high-speed dental turbines, micro-motor hand pieces, ultrasonic scalers and air–water syringes. These produce a large amount of particles and splattering and may contain microorganisms from the oral cavity of patients. It has been suggested that these aerosols contain bacteria and fungi, which may be a risk factor for cross-infection for dental professionals. Bioaerosol compositions are heterogeneous [1]; they contain blood, microorganisms, mucosal cells, restorative materials, tooth particles and large quantities of saliva. Pathogenic microorganisms and microbes from patients' airways may contaminate nearby surfaces and lead to a risk of infectious agent transmission-associated diseases such as influenza, tuberculosis, meningitis or severe acute respiratory syndromes [2].

Some research indicates that dental professionals are exposed to up to 1.86 E + 05 bacteria/m^3 of air [3]. Other research suggests that it may be up to 4.3 E + 05 bacteria/m^3 [4], generated during dental procedures. The small diameter of the aerosol particles (<1 micron) represents a potentially high risk of inhalation of aerosolized bacteria [3].

The mean level of bioaerosols depends on the procedures; higher levels were observed for cavity preparation (24–105 CFU/m^3) and for ultrasonic scaling (42–71 CFU/m^3), and lower levels were reported for extraction (9–66 CFU/m^3) and for oral examination (24–62 CFU/m^3) [5]. However, most research concluded that bioaerosols return to baseline 2 h after the dental treatment [3].

The predominant microorganisms isolated from bioaerosols in dental clinics are *Staphylococcus* and *Micrococcus* species [5,6]. The higher concentration of anti-*Legionella* antibodies reported in dental staff compared with the general population provides evidence that water in dental unit waterlines may be a potential

reservoir for infection [7]. However, it has been reported that sensitization and infectious hazards related to potential long-term exposure to *Legionella* spp. and non-tuberculous mycobacteria are minimal [4,8]. Some studies showed a low prevalence of carriers of methicillin-resistant *Staphylococcus aureus* among dental patients [9].

In the present study, we measured the concentration of bacteria and fungi in aerosols, in rooms where oral surgery was performed using high-speed instruments. The aim of the study was to analyse the number of colony-forming units (CFUs) in bioaerosols and assess whether exposure limits are exceeded.

Methods

Bacterial and fungal aerosols generated during clinical work in two dental offices (a one-chair clinic and a multi-chair clinic) were quantitatively and qualitatively analysed. An extra-oral evacuator system was used. A special filter was placed on the nozzle of the evacuator and air was collected at distances of 30–60 cm from the surgical site to measure total bioaerosol content in dentist's, dental hygienist's and patients' breathing zones.

Inhalable dust samples were collected in the breathing zone of dental practitioners. Control air samples were taken outside the dental practice before and during the working day. Ethical approval was not required for this study.

The identification of isolated bacteria species, based on morphological analysis, was performed. For the macroscopic analysis of colonies, Tryptic Soy Agar was used, with cycloheximide added to inhibit fungal growth. Microscopic analysis of collected bacteria was based on Gram strain preparations and provided data on cell size and shape, orientation to each cell and the appearance of spores. Bacteria were characterized in terms of their metabolic characteristics using the biochemical tests, API (Analytical Profile Index). Their analysis was supported

Table 1. The concentration of bacteria and fungi in aerosols in dental offices before and during patients visits

Collected measurements	Concentration of microorganisms (CFU/m^3)	
	Bacteria	Fungi
A. Dental office no. 1 (multi-chair)		
Outdoor air	260	190
Dental office before patients visit	270	130
Dental office during patients visit	430 (360–500)	300 (0–330)
B. Dental office no. 2 (single chair)		
Outdoor air	150	30
Dentist office before patients visit	180	60
Dentist office during patients visit	490 (200–1190)	110 (40–220)

Table 2. Qualitative characteristic of bacteria and fungi aerosols in dental office no. 1 and outdoor air (control), before and during treatment

The microflora of air in a dental surgery	Bacterial and fungal contamination levels
A. Outdoor air	
Bacteria microflora	% of total bacteria
Gram-positive granulomata	53
Staphylococcus xylosus	25
Micrococcus spp.	15
Staphylococcus lentus	10
Kocuria rosea	3
Gram-positive rod-shaped non-porous bacteria	43
Brevibacterium spp.	28
Corynebacterium striatum	15
Gram-positive rod-shaped bacteria creating endospores	3
Bacillus pumilus	3
Fungal microflora	% of total fungi
Mould fungi	100
Cladosporium cladosporioides	39
Cladosporium herbarum	33
Penicillium griseoazureum	11
Penicillium spp.	11
Fusarium spp.	6
B. Before patients visit	
Bacteria microflora	% of total bacteria
Gram-positive granulomata	100
Staphylococcus epidermidis	52
Micrococcus spp.	33
Streptococcus spp.	11
Staphylococcus xylosus	2
Staphylococcus sciuri	2
Fungal microflora	% of total fungi
Mould fungi	100
Cladosporium cladosporioides	61
Cladosporium herbarum	32
Penicillium griseoazureum	7
C. During patients visit	
Bacteria microflora	% of total bacteria
Gram-positive granulomata	99
Staphylococcus epidermidis	45
Micrococcus spp.	38
Streptococcus spp.	6
Staphylococcus xylosus	5
Staphylococcus equorum	3
Kocuria rosea	2
Mezophile ray fungi	0
Rhodococcus spp.	0
Fungal microflora	% of total fungi
Mould fungi	100
Cladosporium cladosporioides	38
Cladosporium herbarum	31
Penicillium spp.	15
Penicillium griseoazureum	15

Table 3. Qualitative characteristic of bacteria and fungi aerosols in dental office no. 2 and outdoor air (control), before and during treatment

The microflora of air in a dental surgery	Bacterial and fungal contamination levels
A. Outdoor air	
Bacteria microflora	% of total bacteria
Gram-positive granulomata	57
Micrococcus spp.	33
Staphylococcus sciuri	12
Staphylococcus xylosus	9
Kocuria rosea	3
Gram-positive rod-shaped non-porous bacteria	15
Brevibacterium spp.	15
Mezophile ray fungi	15
Rhodococcus	15
Gram-negative rod-shaped bacteria	12
Pseudomonas spp.	12
Fungal microflora	% of total fungi
Mould fungi	100
Cladosporium cladosporioides	67
Penicillium verrucosum	33
B. Before patients visit	
Bacterial microflora	% of total bacteria
Gram-positive granulomata	99
Staphylococcus epidermidis	34
Staphylococcus kloosii	30
Staphylococcus sciuri	15
Micrococcus spp.	11
Staphylococcus lentus	4
Gram-positive rod-shaped non-porous bacteria	4
Brevibacterium spp.	4
Gram-positive rod-shaped bacteria creating endospores	4
Bacillus spp.	4
Fungal microflora	% of total fungi
Mould fungi	100
Cladosporium cladosporioides	83
Penicillium spp.	17
C. During patients visit	
Bacteria microflora	% of total bacteria
Gram-positive granulomata	74
Micrococcus spp.	26
Staphylococcus epidermidis	22
Staphylococcus sciuri	10
Staphylococcus kloosii	5
Staphylococcus xylosus	4
Staphylococcus equorum	2
Kocuria rosea	1
Staphylococcus lentus	1
Streptococcus spp.	1
Gram-positive rod-shaped non-porous bacteria	15
Brevibacterium spp.	15
Gram-positive rod-shaped bacteria creating endospores	9
Bacillus spp.	8
Bacillus circulans	1
Gram-negative rod-shaped bacteria	2
Brevundimonas vesicularis	2
Fungal microflora	% of total fungi
Mould fungi	100
Cladosporium cladosporioides	54
Penicillium verrucosum	27
Penicillium spp.	9
Acremonium spp.	9

using the application APIweb (bioMérieux, Marcy-l'Etoile, France). Bacteria were grouped as Gram-positive cocci, Gram-positive rods that form endospores, non-sporing Gram-positive rods, *Actinomycetes* and Gram-negative bacteria, according to their microscopic morphology.

Identification of fungal strains was conducted based on macroscopic morphological analysis of colonies on an agar base (Malt Extract Agar) and microscopic analysis of colonies (observation of preparations coloured with lactophenol). The identification of isolated strains was based on taxonomic literature review [10–13].

Results

The concentration of total bacterial and fungal aerosols was similar in both dental offices, and a significant increase was observed during dental treatment. The largest proportion of organisms in both of the dental surgeries were Gram-positive cocci which ranged from 74 to 100% of the sample. The remainder were Gram-positive, rod-shaped bacteria and those creating endospores as well as non-porous bacteria.

The dominant fungi were *Cladosporium* and *Penicillium* types. Similar fungal strains were found in the dental offices and the external environment. There were 17 species of bacteria belonging to 10 sub-types and seven species of mould fungi belonging to four sub-types found in the bioaerosols. Most numerous bacteria were *Staphylococci* (six species) and *Bacilli* (three species), and most numerous fungi were *Penicillium* (three species) and *Cladosporium* (two species) (Tables 1–3).

Discussion

The study showed significant increase of the concentration of total bacterial and fungal aerosols during dental treatment. The largest part of bio-spray was Gram-positive granulomata. Human respiratory system and skin are potential sources of these bacteria and the most likely reason for their quantitative domination over the other elements of air microflora. From isolated fungal micro-organisms, the dominating elements were various mould fungi of *Cladosporium* and *Penicillium* type,

which generally occur in interior spaces. However, they also occur in the external environment and may migrate into rooms on personnel's clothes, personnel hair, as well as through room openings. In interior locations, fungal spores may survive for a long period of time on equipment, heating installations, installation components, ventilation and air conditioning systems, preserving their ability to live for several years. Therefore, migration of the air from the external environment into interior spaces is likely to be a key process contributing to biological contamination of the examined spaces.

Qualitative identification of the bio-spray present in both of the examined dental surgeries allowed an evaluation of potential health risks for the dental staff; however, the microorganisms isolated from the air in dental surgeries constitute little risk to the health of the dental professionals [14].

Many studies have shown that bacterial and fungal aerosol concentrations increase during work sessions in dental offices, especially in multi-chair clinics and, therefore, increase the possibility for infectious agent transmission [15,16]. However, the research does not provide evidence of cross-infection generated in dental offices [17]. Nonetheless, preventive measures should be used by dental professionals to reduce aerosols. Measures include using a rinse solution containing 0.12% chlorhexidine (CHX) or 0.05% cetylpyridinium chloride as a pre-procedural mouth rinse [2]. High-volume evacuators (HVEs) are also very effective in minimizing bioaerosol contamination. Additionally, experts highlight that individual methods such as HVE and CHX mouth rinse are very effective at decreasing dental bioaerosols; however, a combination of both methods is even more effective [18].

Potentially hazardous bioaerosols can also be reduced by using an air cleaning system [5,19]. Some research shows that personal particulate respirators (certified in accordance with European Committee on Standardization standard EN 149:2001) are much more effective than high-quality surgical masks commonly used in dental practice [20].

Studies have demonstrated significant differences in awareness about personal immunity status among dental practitioners for some infectious diseases. Checci *et al.* [20] concluded that there should be improved knowledge of immunity status of dental staff and a better vaccination programme. Additionally, past history of infection and immunization history should be known for each individual dental care professional [21]. These measures are commonly provided by occupational health departments.

Research in the UK and USA showed significant gaps in knowledge about infection control and prevention in undergraduate dental students. Infection prevention and control should be an important part of the undergraduate dental curriculum [22]. In the UK, a project was commissioned by NHS Education for Scotland as educational support for health staff [23]. In this study, it was suggested that risk of infectious disease transmission is an integral element of oral health practice [24]. However, these risks can be significantly decreased by applying modern infection control practices which may be technical, organizational and work practice controls. These should, therefore, be a standard part of dental practice.

Key points

- There was a significant increase in the concentration of bacteria and fungi in air during dental treatment sessions.
- The microflora contained mainly Gram-positive organisms, Gram-positive, rod-shaped bacteria and those creating endospores and non-porous bacteria as well as mould fungi.
- Exposure to these microorganisms is not a significant occupational health risk for dental professionals. However, infection control and protection measures should be standard practice in dental surgeries.

Competing interests

None declared.

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