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Nanoparticles in dentistry

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ABSTRACT

Objective. Nanoparticles having a size from 1 to 100 nm are present in nature and are successfully used in many products of daily life. Nanoparticles are also embedded per se or as byproducts from milling processes of larger filler particles in many dental materials.
Methods and Results. Recently, possible adverse effects of nanoparticles have gained increased interest with the lungs being a main target organ. Exposure to nanoparticles in dentistry may occur in the dental laboratory, by processing gypsum type products or by grinding and polishing materials. In the dental practice virtually no exposure to nanoparticles occurs when handling unset materials. However, nanoparticles are produced by intraoral adjustment of set restorative materials through grinding/polishing regardless whether they contain nanoparticles or not. Nanoparticles may also be produced through wear of restorations or released from dental implants and they enter the environment when removing restorations. The risk for dental technicians is taken care of by legal regulations. Based on model worst case mass-based calculations, the exposure of dental practice personnel and patients to nanoparticles through intraoral grinding/polishing and wear is low to negligible. Accordingly, the additional risk due to nanoparticles exposure from present materials is considered to be low. However, more research is needed, especially on vulnerable groups (asthma or COPD). An assessment of risks for the environment is not possible due to the lack of data.
Significance. Measures to reduce exposure to nanoparticles include intraorally grinding/polishing using water coolants, proper sculpturing to reduce the need for grinding and sufficient ventilation of treatment areas.

Contents

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[1] In this review literal citations e.g. from ISO, EU and other documents are used without quotation marks in each case for better readability; respective references are provided.
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1. Introduction

Nanotechnology is the application of scientific knowledge to manipulate and control matter predominantly in the nanoscale to make use of size- and structure-dependent properties and phenomena distinct from those associated with individual atoms or molecules, or extrapolation from larger sizes of the same material [1,2]. Nanomedicine is the controlled use of nanotechnologies in healthcare leading to new pathways for diagnosis and treatment of human diseases [3].

Nanoparticles are present in nature and are used to a large extent in our daily life; e.g. in cosmetic products like sun screens (e.g. TiO_2 or ZnO particles used as UV filter) or in tooth pastes, here mainly titanium dioxide or silicates. But nanoparticles are also present in daily food, dietary supplements and sprays used for coating, cleaning and impregnation [4–8]. They are able to improve e.g. the stability of food, its taste and consistency. Silicon dioxide, magnesium oxide or titanium dioxide are tested and licensed food additives in some countries [9].

In dentistry nanoparticles are playing an increasing role: they are intentionally embedded into products, e.g. to improve material properties of resin-based composites like polishability and gloss stability [10] but also as components for tissue engineering scaffolds [11]. Dental materials, which intentionally release nanoparticles are rather seldom, like scanning sprays for CAD/CAM [12] or occlusion indicator foils. On the other side, nanoparticles can be byproducts from milling processes for fillers. As many dental materials like resin-based composites, cements, or impression materials contain such fillers, it is estimated that nanoparticles are present in about 3500 dental materials (Verband der Deutschen Dental-Industrie (VDDI)—Personal Communication, June 2017).

Use of nanotechnology has a great potential for daily life and worldwide research groups and national/international agencies are putting much effort into this new and highly promising technology (e.g. Refs. [13–17]). More recently, nanoparticles have also become a matter of public and scientific concern and national and international agencies are dealing with nanomaterials and their safety aspects; e.g. WHO,