Nanoparticle Release from Dental Composites during Restoration Grinding and Polishing

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Modern dental composite materials used for tooth restoration are made from a combination of polymer resin with e.g. SiO_2 or ZrO_2 filler particles. In order to be sufficiently strong to withstand chewing and to avoid excessive shrinkage of the composite during polymerization of the resin, the filler particle contents are high, usually >50vol%. While classic dental composites contained filler particles with sizes of several hundred nanometers up to micrometers, current materials typically also contain filler particles below 50nm. When contouring composite restorations using diamond burs, dentists often do not use water-cooling, such that filler particles are released directly into the airborne phase, leading to possible uptake via inhalation by both the dentist and the patient. It was shown in a previous study that release of nanoparticles during polishing or grinding of dental composites is generally possible (Van Landuyt *et al*., 2012). We here present a more thorough study which involved both the measurement of dentists' personal exposure as well as laboratory studies under defined conditions to characterize the particles released from a dental composite during grinding.

To characterize dentists' personal exposure, the number concentration, lung deposited surface area concentration and mean particle size were measured with a miniDiSC. The instrument was sampling through a flexible tube with its inlet placed in the breathing zone of the dentist. Simultaneously, a second miniDiSC instrument was placed approximately 5 m away to monitor particle background. Measurements were performed during extensive restorative/esthetic treatments with the so-called nano-composite Filtek Supreme XTE (3M ESPE), like veneering and total crown build-up of front teeth. Final contouring and finishing of the composite restorations was standardly performed by a diamond bur (roughness of 46-107 µm). Water-cooling and high-flow suctioning using the intra-oral vacuum suctioning device was only occasionally used, according to the standard procedures in the clinic.

The results clearly show that very high concentrations of particles are released during the various mechanical treatment steps of dental composites. The particle number concentrations in the breathing zone showed distinct peaks which could reach up to $>10^6$#/cm³. The concentration spikes usually coincided with a decrease in the mean particle size, indicating that nanoparticles have been released.

In order to better quantify the released material, laboratory measurements were conducted under defined conditions. Five different dental composites were investigated, including a so-called nano-composite (contains only nano-filler) and several (nano-)hybrid composites (contain both large filler and nano-filler particles). Dental composite blocks of defined sizes (17.4mm x 5.4mm x 1.6 mm) were prepared and ground with a rough bur (grain size 100µm), spinning at 200,000 rpm for approximately 2 minutes within an enclosure with low background concentration. The number size distributions of the airborne particles were measured with a Scanning Mobility Particle Sizer (SMPS) and particles sampled for consecutive analyses with an electrostatic precipitator (TSI NAS) with upstream unipolar charger. The investigations revealed that in all cases very high concentrations ($>10^6$ #/cm³) of mostly nanoscale particles were released, which agrees well with the personal exposure measurements. The median diameters of the size distributions during grinding of the different composites ranged from approximately 38 nm to 70 nm, but quickly increased afterwards due to coagulation.

SEM/EDX analyses of the collected samples showed that in some cases single nanoparticles were liberated from the matrix material. In addition the potency of the released material to produce reactive oxygen species (ROS) was measured by electron paramagnetic resonance spectroscopy in order to get an indication on whether the released material is potentially harmful. However, the results showed no increased activity of the material.

Results of the study will be presented and discussed particularly in view of occupational exposure and health risks of dentists.

Van Landuyt KL, Yoshihara K, Geebelen B, Peumans M, Godderis L, Hoet P, *et al*. (2012): Should we be concerned about composite (nano-)dust? *Dental materials : official publication of the Academy of Dental Materials.* **28**:1162-70