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Future Dental Medicine - Nanodentistry

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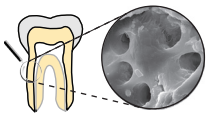
INTRODUCTION

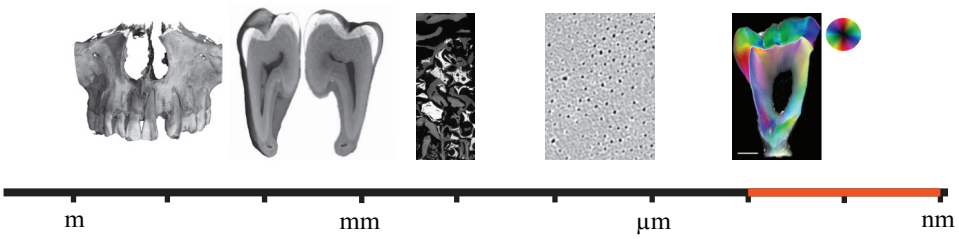


'Nanodentistry' is defined as the science and technology of diagnosing, treating and preventing oral and dental disease, relieving pain, and of preserving and improving dental health, using nanoscale-structured materials [1]. Already in 2000, Freitas [2] introduced the term *nanodentistry* and stated that "new treatment opportunities may include dentition renaturalization, permanent hypersensitivity cure, complete orthodontic realignments during a single office visit, covalently bonded diamondized enamel and continuous oral health maintenance through the use of mechanical dentifrobots".

MATERIALS & METHODS

The common biomaterials are ceramics, metals, and polymers or any kind of combination. Nanoscale patterns on the surfaces and within the volume of the materials accomplish the dedicated functionalities. The fundamental knowledge of the human tissues on the nanometer scale is required to take advantage of these innovative technologies for patients in a nature-analogue manner. Imaging to characterize nanobiomaterials include X-ray tomography, electron microscopy, scanning probe microscopy, X-ray scattering and diffraction methods.

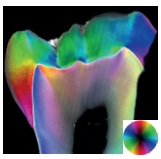
HIERARCHY OF DENTAL STRUCTURES



The nanotechnology generally considers entities between 1 and 100 nm leading to properties and functionalities of materials that fundamentally differ from what is known from larger scales. The surface of the nanoparticles dominates the materials properties, which are usually given by the bulk.

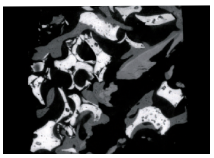
PRESENT APPLICATIONS

(a) Nature-analogue reconstruction

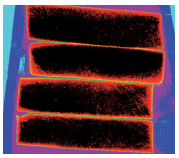


(b) Surface engineered dental implant

(c) Calcium-phosphates for bone augmentation

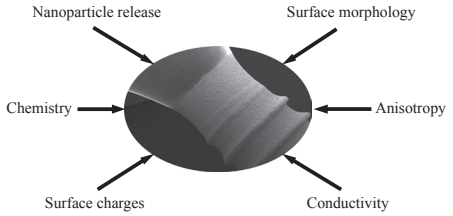


(d) Re-mineralization with nanoparticles



Filling materials for reconstructions, dental root implants, bone augmentation and dentin re-mineralization already take advantage of nanotechnology today, but have increasing growth potential. Today's dental materials will be replaced by nature-analogue, anisotropic tooth restorations. The nanostructures in dentin are orthogonally oriented to the ones of the same size in the enamel [3]. The calcium phosphate phases for bone augmentation gain more and more importance along with the increase in age of the population. The absorbable calcium phosphate phases or bio-glasses support the growth of the natural bone being applied to larger and larger defects. The materials have to be optimized on the micro- and nanometer scales to tweak the biocompability, the bioactivity and the osseoconductivity promoting tissue regeneration. Nanoparticles are already used in 'sensitive' toothpastes and will enable the re-mineralization of damaged teeth [4].

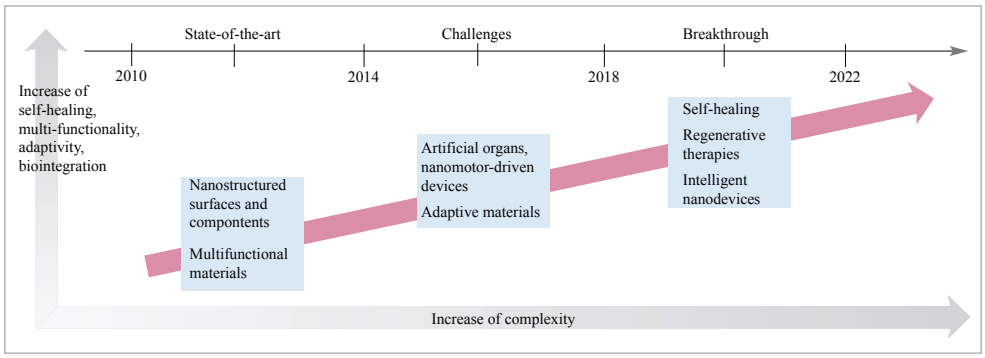
BIOCOMPATIBILITY



Several phenomena can influence the biocompatibility of a dental implant. The implant surface is roughened on the molecular level to foster osseointegration and to reduce the inflammatory reactions [5]. The surface chemistry can be tailored in oxide thickness, stoichiometry and functionalized for hydrophilicity. Further factors are particle release, surface charges, electrical conductivity and anisotropies.

ROADMAP

Biomedical engineers will improve the multifunctional biomaterials to more complex and adaptive ones, so that potential stress-shielding and other non-desired effects are kept away from the affected parts of the body. Engineers will develop intelligent nanoscale systems promoting the self-healing potential of the human body. After the breakthrough around the year 2020 simplifications are expected to lower the degree of complexity and to reduce the costs of nanotechnology-based devices. The application of intelligent nanodevices or nanorobots [1,2] will also enable the desired self-healing capabilities.



CONCLUSION & ACKNOWLEDGEMENT

Nanotechnology has started to a new era of dental medicine that will change the current methods in diagnosis, treatment and prevention of the different patients. As medicine advances and people live longer, nanodentistry will play an increasing role in enabling people to keep their natural teeth and oral tissues healthy and functioning. The scientists will understand in detail how the teeth grow, develop and heal. The medical experts will understand the assembly of nanostructures in dentin and enamel to enable the development of biomimetic tooth repair and regeneration. Dentists will be able to reconstruct hard and soft periodontal tissues as well as to treat caries including biomimetic re-mineralization and repair of diseased teeth.

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