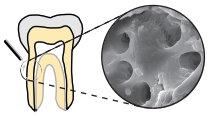
5th European Conference for Clinical Nanomedicine, May 7-9 2012, Basel, Switzerland

Future Dental Medicine - Nanodentistry

Simone E. Hieber[1], Hans Deyhle[1,2], and Bert Müller[1]

[1]*Biomaterials Science Center, University of Basel, Basel, Switzerland*
[2]*Paul Scherrer Institute, Villigen, Switzerland*

INTRODUCTION



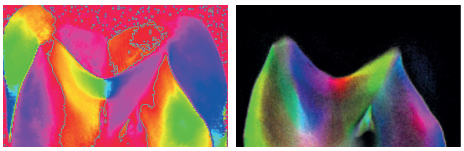
'Nanodentistry' is defined as the science and technology of diagnosing, treating and preventing oral and dental disease, relieving pain, and of preserving and improving dental health, using nanoscale-structured materials [1]. Already in 2000, Freitas [2] introduced the term *nanodentistry* and stated 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 develop innovative technologies for patients.

Imaging to characterize nanobiomaterials include X-ray tomography, electron microscopy, scanning probe microscopy, X-ray scattering and diffraction methods.

ORIENTATION OF NANOSTRUCTURES



Orientations
Colorcode

Collagen

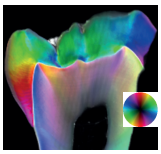
2 mm

Small-angle X-ray scattering (SAXS) of 400 micron thin slices reveals the nano-anatomy of the teeth. The processed scanning signal shows the orientation of nanostructures in the range from 8 to 20 nm. The collagen is characterized by its orientation (color-wheel), scattering intensity (color brightness) and anisotropy (color saturation) of the collagen related signal [3].

The orientation of the scattering signal (left figure) is perpendicular to the nanostructure orientation, while the orientation of the collagen-related signal (right figure) is parallel to the fibers. The future developments of nature-analogue dental materials will consider the nanostructure of teeth to achieve improved long-term results for dental restorations (presented on Swiss TV at SF Einstein on Feb 2012).

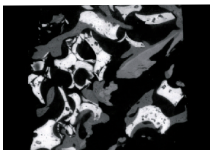
PRESENT APPLICATIONS

(a) Nature-analogue reconstruction

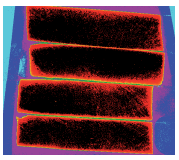


(b) Surface engineered dental implant

(c) Calcium-phosphates for bone augmentation

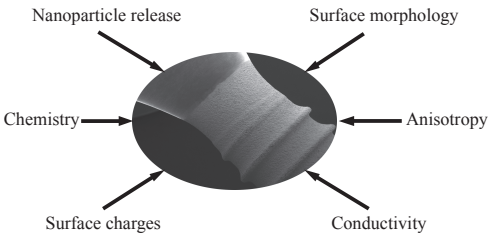


(d) Re-mineralization with nanoparticles



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 [4]. 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 [5].

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 [6]. 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.

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.

The authors thank S. Gaiser, F. Kernen and F. Schmidli for their contributions to the figures.

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