

NanoDentistry: Perspectives on the Role of NanoBiotechnology in Biomaterials, Pharmaceuticals and BioDental Tissue Engineering

Ziyad S. Haidar^{1-4*}

¹*Programa de Magíster en Investigación e Innovación en Ciencias de la Odontología, Facultad de Odontología, Universidad de Los Andes, Santiago de Chile*

²*BioMAT'X, Facultad de Odontología, Universidad de Los Andes, Santiago de Chile*

³*Centro de Investigación Biomédica, Facultad de Medicina, Universidad de Los Andes, Santiago de Chile*

⁴*Plan de Mejoramiento Institucional (PMI) en Innovación I+D+i, Universidad de Los Andes, Santiago de Chile*

***Corresponding Author:** Prof. Dr. Ziyad S. Haidar, DDS, Cert Implantol, MSc OMFS, MBA, PhD; Professor and Scientific Director, Facultad de Odontología, Universidad de los Andes, Mons. Álvaro del Portillo 12.455 - Las Condes, Santiago, Chile. Founder and Head of BioMAT'X (Biomaterials, Pharmaceutical Delivery and Cranio-Maxillo-Facial Tissue Engineering Laboratory and Research Group), Biomedical Research Center (CIB), PMI I+D+i, Department for Research, Development and Innovation, Universidad de los Andes, Mons. Álvaro del Portillo 12.455 - Las Condes, Santiago, Chile.

Received: November 30, 2015; **Published:** December 14, 2015

Nanotechnology, first introduced over half a century ago, helps, at a fundamental level, to manipulate distinct atoms and molecules to design and produce novel structures and materials (size scale ranging 1-100 nm) with unique, improved or desirable physico-chemical, biological and mechanical characteristics and properties. Hence, such an emerging field is rendered diverse, multi- and inter-disciplinary, where it involves the need for a good understanding of biology, chemistry, physics, and mathematics, at the least. Perhaps this explains its delayed introduction, application and utility in Dentistry (when compared to Medicine, for instance). Indeed, it is noted today that extensive research is being carried out Worldwide to understand the advantages and scientific limitations of nanotechnology and its applications to a wide range of disciplines from materials science and biomedical research to space research; thereby witnessing a rapid increase in interest, from scientists, investors, policy makers as well as the general public. On the other hand, nano biotechnology (or bio nano-technology), refers to scientific and technological advances in the intersecting fields of health care and biology, with an emphasis on their interface with nano scale sciences. Dentistry is a branch of medicine with its own peculiarities and very diverse areas of action. The development and use of new techniques and technologies is currently the subject of great interest to practitioners and researchers, alike. In dentistry, nanotechnology and nano biotechnology have recently drawn the attention of scientists and clinicians to potentially significant advances in the detection, prediction, diagnosis, treatment and prevention of oral and maxillofacial diseases. Actually, it is deemed an un-avoidable development in the progress of our art-based on science field. Nanodentistry has been defined as the science and technology of maintaining *near-perfect* oral health through the use of nano materials, nano diagnostics and nano robotics, alongside/including the application of principles of pharmaceuticals, tissue engineering and regenerative medicine. Nano materials are studied to overcome the physical, chemical and mechanical characteristics of conventional dental materials. Nanodentistry possesses a significant potential to yield (soon) a new generation of technologically-advanced clinical tools and devices for oral and maxillofacial healthcare, including: nano robotic localized analgesics (for greater control, patient safety and comfort); nano robotic dentifrice or dentif-robots (for superior and halitosis-free oral health care); orthodontic nano robots (for rapid and painless tooth movement without need for braces); bio-nano-enamel (nano rod -like calcium hydroxyapatite crystals arranged in parallel); nano-electro-mechanical systems (for oral cancer detection and diagnosis); nano vectors and dendrimer nano-particles (for gene and drug delivery in the treatment of oral cancer) and much more "smart" nano biomaterials under development for the treatment of oro-facial fractures, bone augmentation and replacement, cartilage regeneration of the temporomandibular joint, endodontic pulp repair, periodontal ligament regeneration, extraction socket preservation and restoration, salivary gland radioprotection, and implant osseointegration, to list a few potential applications. In conservative and

Citation: Ziyad S. Haidar. "NanoDentistry: Perspectives on the Role of NanoBiotechnology in Biomaterials, Pharmaceuticals and BioDental Tissue Engineering". *EC Dental Science* 3.2 (2015): 506-507.

restorative dentistry, where the most substantial contribution of nanotechnology to dentistry remains to date, is with the implementation or incorporation of nanoparticulate technologies (such as: nano capsules, nano shells, nano pores, nano spheres, nano fillers and nano tubes) into more enhanced tooth structure restorative materials and composite resins; now referred to as “nano composites”. Then again, nano scale topology and quantitative biomechanical or biophysical analysis of dental surfaces are of significant interest. In particular, using atomic force microscopy techniques, where diseases such as dental caries, tooth hypersensitivity, and oral cancer can be quantified based on the morphological, biophysical and biochemical nano scale properties of the tooth surface itself and dental materials or oral fluids such as saliva. The interested reader is invited to keep an eye for ongoing nanodentistry developments such as miniaturized saliva-based diagnostic technologies including salivary exosome-based diagnostics and nano electro-mechanical system biosensors, for example. Endosseous dental implants with nano fiber or anti-microbial coatings as well as new chitosan and silver nanotechnology chemistries (proven to be effective against endodontic microbes and oral biofilms) are also other exciting advances to watch for. It is note worthy here in that often, nano dentistry can be approached in two ways: “top-down” and/or “bottom-up”. Briefly, the earlier approach has resulted in remarkable breakthroughs such as the rapid development of the semiconductor industry, prosthetic implants, nano needles and nano composites. However, its future impact will mainly depend on how quickly current lithographic technologies are advanced. On the other hand, much progress has been made in integrating nanostructured materials into larger systems; i.e. the “bottom-up” approach. It basically refers to the construction of macromolecular structures from atoms or molecules that self-assemble to form macroscopic structures; i.e. molecular and DNA nano technologies, nano diagnostics, nano robotics, localized drug/gene delivery and bio dental tissue engineering. Therefore, with such demonstrated progress, major advances and optimism that nanotechnology applied to dentistry brings and will continue to bring; it is safe to say that nanodentistry will make possible the diagnosis, maintenance and treatment (or prevention of disease) of comprehensive oral health via employing nanotissue devices which will allow precise, predictable and controlled oral health care, perhaps, all in a single office visit; thereby revolutionizing the art and science of dentistry.

Closing Remarks

Nanotechnology is changing global health care via introducing new and innovative methods service able in disease detection, diagnosis and prevention, drug delivery, tissue engineering and gene therapy. Nano dentistry is clearly multidisciplinary and interdisciplinary building on existing knowledge and expertise in different scientific and technological fields. With the persistent refinement of traditional approaches, development of advanced biomaterials and new tools and pharmacological formulations will continue to improve oro-dental practice and care. This would provide dentists with more precision-made and tailored materials, drugs and equipment by which both, safety and patient compliance are enhanced. Yet, concerns do exist. As with any other technology, nanodentistry may also carry a potential for abuse and/or misuse, raising ethical and human safety/biocompatibility issues. Hence, along with such technological developments, formal interdisciplinary training programs should go in parallel, to further enrich and boost basic knowledge in biomaterials, cellular and molecular biology/physiology, biophysics, drug delivery, tissue engineering and regenerative medicine for enhanced proficiency in handling the new nano biomaterials and techniques.

Acknowledgements

This work was supported by generous funding/operating grants provided to the BioMAT'X (Biomaterials, Pharmaceutical Delivery and Cranio-Maxillo-Facial Tissue Engineering Laboratory and Research Group), part of CIB (Centro de Investigación Biomédica), through the Faculty of Dentistry and PMI (Plan de Mejoramiento Institucional en Innovación I+D+i), Dirección de Innovación, Universidad de Los Andes, Santiago, Chile.

Volume 3 Issue 2 December 2015

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