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EDITORIAL

Nanomedicine–Next Generation Technology Revolutionizing Medical Practice

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Nanomedicine has been defined as ''the monitoring, repair, construction, and control of human biological systems at the molecular level, using engineered nanodevices and nanostructures''. Therefore, nanomedicine adopts the concepts of nanoscale manipulation and assembly to applications at the clinical level of medical sciences. In a broad sense, nanomedicine is the application of nanoscale technologies to the practice of medicine. It is used for the diagnosis, prevention, and treatment of disease and to gain an increased understanding of complex underlying disease mechanisms. Nanomaterials are now being designed to aid the transport of diagnostic or therapeutic agents through biologic barriers; to gain access to molecules; to mediate molecular interactions; and to detect molecular changes in a sensitive, high throughput manner. With nanomaterials, the high ratio of surface area to volume permits high surface loading of therapeutic agents; in the case of organic nanomaterials, their hollow or porous core allows encapsulation of hundreds of drug molecules within a single carrier particle.

The application of micro- and nanobiotechnology in medical diagnostics can be subdivided into three areas: in vitro diagnostics, in vivo diagnostics and medical devices. In vivo diagnostics refers in general to imaging techniques, but also covers implantable devices. Nano-imaging or molecular imaging includes techniques for the study of molecular events in vivo and for molecule manipulation. The main benefits of molecular imaging for in vivo diagnostics are the early detection of diseases and the monitoring of disease stages (e.g. in cancer metastasis), leading to individualised medicine and real-time assessment of therapeutic and surgical efficacy. Targeted molecular imaging is important for a wide range of diagnostic purposes, such as the identification of the locus of inflammation, the visualisation of vascular structures, fracture lines or specific disease states and the examination of anatomy. Nanotechnology also has many implications for in vivo diagnostic devices such as the swallowable imaging, diagnostic and therapeutic 'pill' and new endoscopic instruments. Minimally invasive image guided therapy using navigation technologies and advanced multi-modal imaging will improve accuracy and outcome of therapy. Autonomous power, self-diagnosis, remote control and external transmission of data are other considerations in the development of these devices. Imaging probes that allowed for greater tissue specificity, greater resolution in tissues of interest and greater control over half-life are possible.

Nanotechnology also allows for improvement of non-resorbable biomaterials and effective manipulation of biological interactions at the nanometer level, which will dramatically increase the functionality and longevity of implanted materials. By applying bioactive nanoparticle coatings on the surface of implants, it will be possible to bond the implant more naturally to the adjoining tissue and significantly prolong the implant lifetime. And it might be possible to surround implanted tissue with a nanofabricated barrier that would prevent activation of the rejection mechanisms of the host, allowing a wider utilisation of donated organs and graft materials after reconstruction. This is helpful in reconstruction of maxillofacial defects as screw loosening and infection and rejection of graft material can be minimized with materials made using nanotechnology.

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The potential for the use of nanotechnology in surgery is huge. Surgeons are constantly looking for minimally invasive ways to treat their patients, as recovery is faster when a lesser trauma is inflicted upon a patient, scarring is lessened and there are usually fewer complications in the aftermath of the operation. Surgeons operate on the macro scale, and have made great advances over the last century. Surgery has evolved from "no more science than butchery" to a highly respected science, and even an art. Through nanotechnology, tiny biosensors could be constructed which could take these factors into account, thus shortening a patients recovery period and saving hospitals expenditure, reducing nosocomial infection rates, reducing the waiting lists for operation and allowing doctors to treat more patients in the same period of time.

A surgical nanobot, programmed by a human surgeon, could act as an autonomous on-site surgeon inside the human body. Various functions such as searching for pathology, diagnosis and removal or correction of the lesion by nanomanipulation can be performed and coordinated by an on-board computer.

The performance of surgical blades can be enhanced significantly when microstructured hardmetal is coated with diamond and processed. Major advantages of the diamond nano-layers in this application are low physical adhesion to materials or tissues and chemical/biological inertness. In addition, diamond has a low friction coefficient decreasing the penetration force necessary. Nanoneedles prepared from silicon and attached to an atomic force microscope can be used to penetrate the nucleus of living cells to deliver molecules and may be even used to carry out cell surgery. Typical sizes of these nanoneedles are 200–300 nm in diameter, and 6–8 μm in length.

Nanowires can be engineered to sense and pick up molecular markers of cancer cells and pinpoint the changes in the genetics of cancer. The nanometer-sized cantilevers are extremely sensitive and can detect single molecules of DNA or protein. Thus providing fast and sensitive detection methods for cancer related molecules. Nanoparticle contrast agents are being developed for tumor detection purposes. Super paramagnetic nanoparticles are used for magnetic resonance imaging.

Nanomedicine for cancer therapy is advantageous over conventional medicine because it has the potential to enable the preferential delivery of drugs to tumors owing to the enhanced permeability and retention effect, and the delivery of more than one therapeutic agent for combination therapy. Other advantages of nanomedicine include specific binding of drugs to targets in cancer cells or the tumor micro environment, simultaneous visualization of tumors using innovative imaging techniques, enhanced drug-circulation times, and controlled drug-release kinetics, and superior dose scheduling for improved patient compliance. Nanomedicine has the potential to overcome these problems.

One of the greatest achievements of nanotechnology in surgery will be what we call the "ideal graft"; that is, biocompatible and durable "repairs" of parts of the body like arteries, joints or even organs. At first, these repairs will be used for healing, but soon afterwards, they will be used for transcendence: to enhance current human abilities. This trend is already apparent in plastic surgery that aims at appearance enhancement. Expect this trend to appear in other surgical specialties, like orthopedics for enhanced athletes, transplantation of organs from bioprinting or stem cells, new coronary arteries delivered with angioplasty balloons, enhancement drugs with DNA modifications, and many many others.

The nanotechnology will be helpful to oral and maxillofacial surgeon in following ways

(1) Head and neck cancer—because of nanodiagnostics early and pinpoint detection of site of cancer will be possible and this will lead to better planning of surgery and less morbidity to patient thus increasing post operative quality of life of patient.
    Will be helpful in diagnosis of metastatic lesions.
    Targeted drugs will deliver drugs to exact cancer site thus sparing healthy tissues and reducing side effects and complications.
(2) Cysts and tumors—here exact relationships of lesion with adjacent structures such as root apices, maxillary sinus or inferior alveolar canal can be detected leading to reduced post operative paresthesia.
    And in case of locally aggressive lesions such as OKC and ameloblasoma level of infiltration in adjacent tissues can be located leading their complete removal and reducing chances of recurrence.
(3) It may help in prediction of growth pattern which will be helpful in early intervention better planning with better results in genetic deformities, orthognathic and cleft surgery cases.
(4) Nanotechnology will help in development of tissue engineering and lead to ideal reconstruction of defects with no donor site morbidity and provide natural replacement to lost anatomic structures.
(5) Targeted drug delivery can increase effectiveness of treatment of trigeminal neuralgia, HIV and many other diseases including cancer.

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