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Nanotechnology has potential to revolutionise orthopaedics – experts call for research into safety

Targeted treatment of bone tumour cells, quantum dots that make individual molecules visible, using polymers to encourage tissue growth: nanotechnology has the potential to revolutionise orthopaedics. But the question of patient safety still needs to be clarified, according to experts at the EFORT Congress in London.

London, 5 June 2014 – "Nanotechnology holds enormous potential for orthopaedics. But the key question is, can we be sure it won't cause harm to patients over the long term? Rigorous safety studies are essential," commented Prof Nicola Baldini of the Rizzoli Orthopaedic Institute and the University of Bologna, at the 15th EFORT Congress in London. The Congress is organised by the European Federation of National Associations of Orthopaedics and Traumatology (EFORT), this year in partnership with the British Orthopaedic Association (BOA). Patient safety is the main theme of this major scientific gathering, which has attracted 7,000 experts from all over the world to the British capital. A session organised by the European Orthopaedic Research Society (EORS) was dedicated to nanotechnology and nanoscience.

The use of nanotechnology in orthopaedic surgery is by no means science fiction: "Nanoscience is making its way into many key areas of orthopaedics, including in clinical practice. Research into therapies that involve the manipulation of individual genes or the molecular pathways that influence their expression is on the rise," Prof Baldini reported. Recombinant technology that produces humanised antibodies to reduce bone resorption is already in use. And the emerging field of exosome science and technology is a good example of how biotechnology and nanotechnology can be combined. Exosomes are subcellular structures that are released by cells within the body and carry proteins, such as growth factors, acting as carriers of information and able to activate target cells.

Targeting tumour cells

Most nanotechnology applications are still very much in the development phase, but a number of highly promising approaches are emerging. Photoactivation of fluorescent molecules that interact with subcellular nanoengines may be an effective way to treat bone cancer. "One highly sought goal in this field is the ability to tailor treatments according to the genetic make-up of individual patients. This is already possible in theory, but at present it is extremely expensive," commented Prof Baldini.

Nanocarriers have been developed to deliver biologically active materials directly to the location where they can be beneficial, for example to target bone tumours, enabling specific delivery of cytotoxic drugs or therapeutic molecules. "This approach has huge potential, because it means that we could avoid damaging healthy cell tissue," Prof Baldini explained.

Nanoimaging opens up new perspectives

The convergence of nanotechnology and medical imaging is set to spark a revolution in molecular imaging in the near future. Known as nanoimaging, such techniques will enable detection of individual molecules or cells within a complex biological environment, for example using fluorescent nanocrystals such as quantum dots. These are nanoparticles that can target a specific tissue or cell and be made to fluoresce for imaging purposes.

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"Researchers have high expectations for quantum dots, which should be particularly useful in imaging of living tissue, where signals are often obscured, producing unclear images," explained Prof Baldini.

Stronger, lighter and anti-infective: nanostructured materials

Nanostructured materials also deliver a whole range of options for improving orthopaedics. The surface properties of implants can be enhanced so that they are more conducive to osteoblast function, encouraging bone ingrowth. Biomimetic functionalised polymers that mimic the extracellular matrix in bone tissue are being developed for tissue engineering scaffolds. And nanotechnology also means that materials can be stronger and lighter in the future: "For example, carbon nanotubes have the same stiffness as diamonds, and they are a hundred times stronger than steel – but only a sixth of its weight," said Prof Baldini. Nanostructured ceramics can reduce friction and wear problems associated with artificial joint replacements. Another promising innovation is nanocrystalline silver membrane wound dressings, which aim to reduce postoperative infection rates and promote faster healing. Implant nanocoatings containing cytokines have been developed that prevent infection by enhancing activation of macrophages, which play a crucial role in the immune system.

Patient safety: research still at an early stage

"While these new technologies are attracting plenty of enthusiasm, it is important to remember that studies investigating nanophase materials have only just begun," Prof Baldini emphasised. Since nanoparticles are smaller than the pores in many types of biological tissue, thorough safety testing is required. Such particles may easily become dislodged from implants. "Probably the greatest potential risk is posed by nanomaterials that contain inorganic metals and oxides. Nanoparticles are highly reactive, and may trigger as yet unknown chemical reactions," he pointed out. Additionally, the metabolism of nanoparticles has been shown to involve various organ systems, including the blood, liver and kidneys, and could result in inflammation and oxidative stress. The effects of nanoparticle debris on local tissue are uncertain, and have been connected with brain and lung toxicity. "Regardless of its immense potential and the leading role played by Europe in developing this technology of the future, the critical question is whether we can understand the possible long-term consequences of using such products. An innovative field such as nanotechnology calls for truly interdisciplinary efforts," Prof Baldini concluded.

About EFORT

The European Federation of National Associations of Orthopaedics and Traumatology (EFORT) is the umbrella organisation linking Europe´s national orthopaedic societies. EFORT was founded in 1991 in the Italian Marentino. Today it has 45 national member societies from 42 member countries and eleven associate scientific members.

EFORT is a non-profit organisation. The participating societies aim at promoting the exchange of scientific knowledge and experience in the prevention and treatment of diseases and injuries of the musculoskeletal system. EFORT organises an annual congress, seminars, courses, forums and conferences within Europe. It also initiates and supports basic and clinical research.

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