UC San Diego Engineers Develop Novel Method for Accelerated Bone Growth

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Engineers at the University of California at San Diego have come up with a way to help accelerate bone growth through the use of nanotubes and stem cells. This new finding could lead to quicker and better recovery, for example, for patients who undergo orthopedic surgery.

In recent years, stem cells have become a hot topic of investigation with studies suggesting revolutionary medical benefits due to their ability to be converted into selected types of newly generated cells. During their research, the group of UC San Diego bioengineers and material science experts used a nano-bio technology method of placing mesenchymal stem cells on top of very thin titanium oxide nanotubes in order to control the conversion paths, called differentiation, into osteoblasts or bone building cells. Mesenchymal stem cells, which are different from embryonic stem cells, can be extracted and directly supplied from a patient's own bone marrow.

The researchers described their lab findings in a paper published this week in the Proceedings of the National Academy of Sciences (PNAS), "Stem Cell Fate Dictated Solely by Altered Nanotube Dimension."

"If you break your knee or leg from skiing, for example, an orthopedic surgeon will implant a titanium rod, and you will be on crutches for about three months," said Sungho Jin, co-author of the PNAS paper and a materials science professor at the Jacobs School of Engineering. "But what we anticipate through our research is that if the surgeon uses titanium oxide nanotubes with stem cells, the bone healing could be accelerated and a patient may be able to walk in one month instead of being on crunches for three months.

"Our in-vitro and in-vivo data indicate that such advantages can occur by using the titanium oxide nanotube treated implants, which can reduce the loosening of bones, one of the major orthopedic problems that necessitate re-surgery operations for hip and other implants for patients," Jin added. "Such a major re-surgery, especially for older people, is a health risk and significant inconvenience, and is also undesirable from the cost point of view."

This is the first study of its kind using stem cells attached to titanium oxide nanotube implants. Jin and his research team - which include Jacobs School bioengineering professors Shu Chien and Adam Engler, as well as post doctoral researcher Seunghan Oh and other graduate students and researchers -report that the precise change in nanotube diameter can be controlled to induce selective differentiation of stem cells into osteoblast (bone-forming) cells. Karla Brammer, a Jacobs School materials science graduate student, will also present these findings in a poster session during Research Expo on February 19.

According to this breakthrough research, nanotubes with a larger diameter cause cells growing on their surface to elongate much more than those with a small diameter. The larger diameter nanotube promotes quicker and stronger bone growth. "The use of nano topography to induce preferred differentiation was reported in recent years by other groups, but such studies were done mostly on polymer surfaces, which are not desirable orthopedic implant materials," Jin said.

It is common for physicians and surgeons to use chemicals for stem cell implants in order to control cell differentiation, a conversion into a certain desired type of cells, for example, to neural cells, heart cells, and bone cells. However, introducing chemicals into the human body can sometimes have undesirable side effects. "What we have accomplished here is a way to introduce desirable guided differentiation using only nanostructures instead of resorting to chemicals," said Seunghan (Brian) Oh, who is the lead author of the PNAS article.

The next step for engineers will be to work with orthopedic surgeons and other colleagues at the UC San Diego School of Medicine to study ways to translate this breakthrough research to clinical application, said Shu Chien, a UC San Diego bioengineering professor and director of the university's new Institute of Engineering in Medicine (IEM). Chien said this effort will be fostered by the IEM, whose goal is to bring together scientists, engineers and medical experts to come up with novel approaches to medicine.

"Our research in this area has pointed to a novel way by which we can modulate the stem cell differentiation, which is very important in regenerative medicine," Chien said. "This will lead to a truly interdisciplinary approach between engineering and medicine to getting novel treatments to the clinic to benefit the patients."

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