New generation of orthopedic, dental and cardiovascular prostheses

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The futuristic technology of the Six Million Dollar Man -specifically a part metal and part flesh human being - won't be exclusive to Hollywood anymore. While the main character in the Six Million Dollar Man was outfitted with metals to enhance his performance, a multidisciplinary team of scientists led by the Université de Montréal has discovered a process to produce new metal surfaces that promise to lead to superior medical implants that will improve healing and allow the human body to better accept metal prostheses.

According to new research published in *Nano Letters*, the scientists capitalized on recent advances in nanotechnology to change how metals can influence cell growth and development in the body. A critical aspect of the finding is that the surfaces can directly stimulate cells - thereby eliminating the need for pharmaceuticals and resulting side-effects. The study is a collaboration between the Université de Montréal, McGill University, the Institut National de la Recherche Scientifique (INRS-EMT), Plasmionique Inc and the Universidade de São Paulo.

"Using chemical modification, we have produced metals with intelligent surfaces that positively interact with cells and help control the biological healing response," says Antonio Nanci, the study's senior author and a professor at the Université de Montréal's Faculty of Dentistry. "These will be the building-blocks of new and improved metal implants that are expected to significantly affect the success of orthopedic, dental and cardiovascular prostheses."

Etching produces nanoporous surfaces

Dr. Nanci and colleagues applied chemical compounds to modify the surface of the common biomedical metals such as titanium. Exposing these metals to selected etching mixtures of acids and oxidants results in surfaces with a sponge-like pattern of nano (ultra small) pits. "We demonstrated that some cells stick better to these surfaces than they do to the traditional smooth ones," says Dr. Nanci. "This is already an improvement to the standard available biomaterial."

The researchers then tested the effects of the chemically-produced nanoporous titanium surfaces on cell growth and development. They showed that the treated surfaces increased growth of bone cells, decreased growth of unwanted cells and stimulated stem cells, relative to untreated smooth ones. In addition, expression of genes required for cell adhesion and growth were increased in contact with the nanoporous surfaces.

Different etchants have different effects

Uncontrolled growth of cells on an implant is not ideal. For example, when using cardiovascular stents, it is important to limit the growth of certain cells in order not interfere with blood flow. Also, in some cases, cells can form an undesirable capsule around dental implants causing them to fall. The scientists demonstrated that treatment with specific etchants reduced the growth of unwanted cells.

"An important element of this study is how we demonstrated the selective cellular effects of etching," says Dr. Nanci. "With subtle changes in chemical composition of etching mixtures, we can alter the nanopatterns that are created on the metal surface and control consequent cellular responses."

"Our study is groundbreaking," adds Dr. Nanci. "We use simple yet very efficient chemical treatments to alter metals commonly used in the operating room. This innovative approach may ultimately hold the key to developing intelligent materials that are not only easily accepted by the human body but that can actively respond to the surrounding biological environment."

The article "Nanoscale Oxidative Patterning of Metallic Surfaces to Modulate Cell Activity and Fate" was published in Nano Letters. pubs.acs.org/journal/nalefd?cookieSet=1

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