High-strength silk scaffolds improve bone repair

April 30 2012

Biomedical engineers at Tufts University's School of Engineering have demonstrated the first all-polymeric bone scaffold material that is fully biodegradable and capable of providing significant mechanical support during repair. The new technology uses micron-sized silk fibers to reinforce a silk matrix, much as steel rebar reinforces concrete. It could improve the way bones and other tissues are repaired following accident or disease.

The discovery is reported in the *Proceedings of the National Academy of Sciences* Online Early Edition the week of April 30-May 4, 2012.

In the U.S. an estimated 1.3 million people undergo bone graft surgeries each year, notes the paper.

Human bones are hard but relatively lightweight, able to withstand considerable pressure while being sufficiently elastic to withstand moderate torsion. Inside the hard, mineralized tissue is a matrix in which bone cells can proliferate and adhere. Natural bone is the obvious choice for grafts.

However autologous grafts mean putting the patient through additional surgery and the supply of self-donated tissue is, obviously, limited. Donor grafts pose risks of disease, graft rejection and other long-term complications.

A handful of all-polymeric biomaterials, such as collagen, are currently used for bone regeneration, but they lack strength. Incorporating ceramics or metals into polymers improves mechanical properties but such composites often sacrifice optimum bone remodeling and regeneration.

By bonding silk protein microfibers to a silk protein scaffold, the Tufts bioengineers were able to develop a fully biodegradable composite with high-compressive strength and improved cell responses related to bone formation in vitro.

The study found that silk microfiber-protein composite matrices mimicked the mechanical features of native bone including matrix stiffness and surface roughness that enhanced human mesenchymal stem cell differentiation compared to control silk sponges. In combination with inherent silk fiber strength, compact fiber reinforcement enhanced compressive properties within the scaffolds.

"By adding the microfibers to the silk scaffolds, we get stronger mechanical properties as well as better bone formation. Both structure and function are improved," said David Kaplan, Ph.D., chair of biomedical engineering at Tufts University. "This approach could be used for many other tissue systems where control of mechanical properties is useful and has broad applications for regenerative medicine."

Other authors on the paper were Biman B. Mandal, former post doctoral associate in the Department of Biomedical Engineering at Tufts and now in the Department of Biotechnology, Indian Institute of Technology; visiting biomedical engineering student Ariela Grinberg, who recently completed her degree in the Department of Tissue Engineering, Cell Therapy and Regenerative Medicine at the National Institute of Rehabilitation, Mexico; and Eun Seok Gil and Bruce Panilaitis, research associate and research assistant professor respectively in the Department of Biomedical Engineering at Tufts.

The Tufts scientists used a novel approach to manufacturing the silk microfibers: applying alkaline hydrolysis (the use of alkali chemicals to break down complex molecules into their building blocks). This greatly reduced the time and cost of making the microfibers in a variety of sizes. Microfibers ranging from 10 to 20 um were obtained in one minute, compared with production of 100 um plus size fibers after 12 minutes of conventional processing.

Although significant improvements in compressive properties were observed in the silk composite scaffolds, values were still significantly lower than that of stronger native bone. The Tufts researchers suggest that such scaffolds can play a valuable role as temporary biodegradable support for native cells to grow and replace.

More information: *Proceedings of the National Academy of Sciences* Early Edition. doi/10.1073/pnas.1119474109

Provided by Tufts University