Printing Bone, Muscle and More

A Pittsburgh-based research team has created and used an innovative ink-jet system to print “bio-ink” patterns that direct muscle-derived stem cells from adult mice to differentiate into both muscle cells and bone cells.

The custom-built ink-jet printer, developed at Carnegie Mellon’s Robotics Institute, can deposit and immobilize growth factors in virtually any design, pattern or concentration, laying down patterns on native extracellular matrix-coated slides (such as fibrin). These slides are then placed in culture dishes and topped with muscle-derived stem cells (MDSCs). Based on pattern, dose or factor printed by the ink-jet, the MDSCs can be directed to differentiate down various cell-fate differentiation pathways (e.g. bone- or muscle-like).

“This system provides an unprecedented means to engineer replacement tissues derived from muscle stem cells,” said Johnny Huard [1], professor of orthopedic surgery at the University of Pittsburgh School of Medicine and director of the Stem Cell Research Center at Children’s Hospital of UPMC. Huard has long-standing research findings that show how muscle-derived stem cells (MDSCs) from mice can repair muscle in a model for Duchenne Muscular Dystrophy, improve cardiac function following heart failure, and heal large bone and articular cartilage defects.

Weiss and Campbell, along with graduate student Eric Miller, previously demonstrated the use of ink-jet printing to pattern growth factor “bio-inks” to control cell fates. For their current research, they teamed with Phillippi, Huard and biologists of the Stem Cell Research Center at Children’s Hospital to gain experience in using growth factors to control differentiation in populations of MDSCs from mice.

The team envisions the ink-jet technology as potentially useful for engineering stem cell-based therapies for repairing defects where multiple tissues are involved, such as joints where bone, tendon, cartilage and muscle interface. Patients afflicted with conditions like osteoarthritis might benefit from these therapies, which incorporate the needs of multiple tissues and may improve post-treatment clinical outcomes.

The long-term promise of this new technology could be the tailoring of tissue-engineered regenerative therapies. In preparation for preclinical studies, the Pittsburgh researchers are combining the versatile ink-jet system with advanced real-time live cell image analysis developed at the Robotics Institute and Molecular Biosensor and Imaging Center [2] to further understand how stem cells differentiate into bone, muscle and other cell types.

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