Tissue-Engineered Cartilage – A Perspective on Translating Research to Patents and the Marketplace

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Tissue engineering describes the strategy of producing an organized matrix and tissue-like substance from the combination of three dimensional biomaterial scaffolds with cells after incubating in vitro or in vivo. While tissue such as cartilage may be considered relatively simple compared to the heart or liver, they still present challenges to the engineer and the technology has not yet reached clinical use. We are investigating hydrogel-based materials that can form in joint (cartilage) defects in situ. In addition to studying different biological-synthetic combination hydrogels, we are evaluating different cell types that may be applied to skeletal tissue engineering, including stem cells. These composite scaffolds we have generated comprise physical, ionic, and covalent crosslinking synthetic and biological polymers. By rational design of these composite materials, biological signals to promote tissue regeneration can be designing into a scaffold. While the signals to induce adult (marrow-derived) stem cells to cartilage and bone have been discovered by scientists and can be translated to tissue engineering systems, little is know how embryonic stem cells operate. Therefore, we have dedicated significant energy to understand how embryonic cells differentiate towards musculoskeletal tissues and created an embryonic mesenchymal-like stem cell. Furthermore, we found that the signals required for embryonic cell-based tissue engineering are significantly different than those for adult stem cells. The embryonic cells (both stem and germ) show significant promise for musculoskeletal tissue engineering with their strong proliferative and differentiation capacity. As a twist to the standard application of tissue engineering for repair and regenerative medicine applications, we are also utilizing tissue engineering as a vehicle to study disease. Mimicking disease abnormalities in vitro provides a venue for us to probe the mechanism of disease and also evaluate potential therapeutics such as stem cells for normalizing diseased tissue development.

Finally, to accelerate translation of tissue engineering and biomaterial technologies we have combined surgical techniques that promote endogenous stem cell activity with bioactive materials. These technologies and materials have the potential to greatly enhance repair strategies. However, to accomplish this translation of regenerative medicine strategies to clinical application in the challenging environment of the musculoskeletal system, there was a need to develop biological tissue adhesives. Chondroitin sulfate, a major extracellular matrix proteoglycan in tissue, was chemically modified to form hydrogels and also to react with the surrounding tissues to integrate the scaffold with the host. Because of the biological nature of these adhesives, cellular activity/tissue formation was improved in addition to the physical stabilization. This technology was transferred (licensed) to the startup company Cartilix Inc.

In sum, regenerative medicine strategies require the input of numerous disciplines including chemistry, engineering, biology, and medicine and they have the potential to significantly improve basic understanding of tissue development in addition to improving clinical therapies and patient care.