Monitoring Tissue Engineering Using Magnetic Resonance Imaging

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Assessment of tissue regeneration is essential to optimize the stages of tissue engineering (cell proliferation, tissue development and implantation). Optical and X-ray imaging have been used in tissue engineering to provide useful information, but each has limitations: for example, poor depth penetration and radiation damage. Magnetic resonance imaging (MRI) largely overcomes these restrictions, exhibits high resolution (approximately 100 μm) and can be applied both *in vitro* and *in vivo*. Recently, MRI has been used in tissue engineering to generate spatial maps of tissue relaxation times (T_1, T_2), water diffusion coefficients, and the stiffness (shear moduli) of developing engineered tissues. In addition, through the use of paramagnetic and superparamagnetic contrast agents MRI can quantify cell death, assess inflammation, and visualize cell trafficking and gene expression. After tissue implantation MRI can be used to observe the integration of a tissue implant with the surrounding tissues, and to check for early signs of immune rejection. In this presentation, I will describe and evaluate the growing role of MRI in the assessment of tissue engineered constructs. First, I will briefly describe the underlying principles of MRI and the expected changes in relaxation times (T_1, T_2) and the water diffusion coefficient that are the basis for MR contrast in developing tissues. Next, I will describe how MRI can be applied to evaluate the tissue engineering of mesenchymal tissues (bone, cartilage, and fat). Finally, I will outline how MRI can be used to monitor tissue structure, composition, and function to improve the entire tissue engineering process.