Cartilage Repair and Computational Modeling

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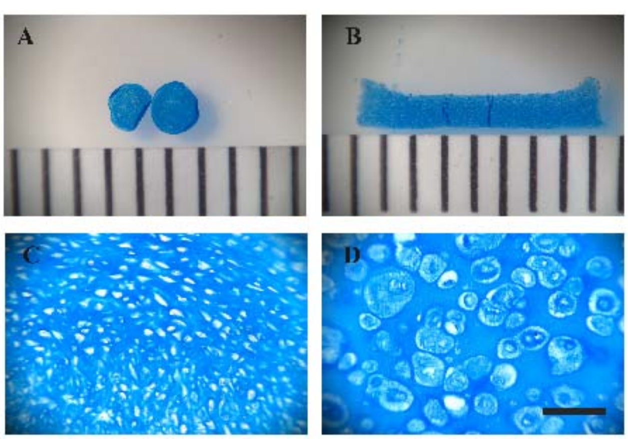
Unlike other connective tissues, articular cartilage appears to have a limited capacity for intrinsic repair once injured or degenerated. Damage to the tissue in diarthrodial joints is thus believed to be progressive with significant pain and joint dysfunction resulting. The Orthopaedic Research Laboratory at Virginia Commonwealth University is applying the principles of tissue engineering for articular cartilage repair (chondrogenesis), focussing on the development of scaffolds and inducing cellular infiltration/proliferation in the scaffolds. Two techniques are underway. The first involves electrostatic spinning (electrospinning) which provides the opportunity for control over morphology, porosity, and composition of the scaffold of submicron diameters. Electrospun scaffolds, composed of either absorbable polymers or natural biomaterials, are seeded with native chondrocytes, the cells of articular cartilage. This electrospinning is performed in conjunction with the Tissue Engineering Laboratory at VCU. The second technique exploits the documented potential for bone marrow-derived cells for chondrogenesis. These cells are seeded into three-dimensional porous scaffolds consisting of polylactic acid/alginate amalgams. The invitro design of seeded scaffolds for both techniques are being optimized and evaluated invivo.

Computational tools in biomechanics provide an efficient way to assess biomechanical behavior of tissues and/or structures without physical experimentation. Finite element analysis in solid mechanics links the deformation (strain) that a structure or tissue undergoes due to the loads (stress) applied to it. The Orthopaedic Research Laboratory at Virginia Commonwealth University applies the computational modelling tool known as finite element analysis to understand the biomechanical function of different musculoskeletal tissues. Primary interests are in normal and repair cartilage mechanics. These analyses provide the means to assess how mechanical properties, both linear and nonlinear, contribute to overall cartilage function. Additionally, comparison of the behavior of normal articular surfaces with surfaces comprising a region of repair cartilage (with inferior properties) enables determining the functions that are specifically altered. These analyses also allow for evaluation of different repair techniques, once the properties of the generated repair tissue are know. This information leads us to develop better reparative methods.



Histologic evaluation of cartilage growth (blue stain) in PLA scaffolds seeded with stem cells from bone marrow aspirates. For cartilage repair (NIH funded).