

Biphasic constructs for cartilage repair

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Damage to articular cartilage, either by trauma or disease, can affect joint function as adult articular cartilage has a limited capacity for repair. Currently resurfacing the articulating surfaces of synovial joints with synthetic prostheses still represents the optimal treatment for end-stage disease.¹ Although primary joint replacements have shown reasonable success rates, these have their limitations as failure rates of up to 20% after 10 years have been reported depending on the type of implant.² It has been speculated that all joint replacements made of synthetic materials will need replacement if the patient lives long enough. Furthermore, this treatment is not appropriate for focal defects. Recent efforts have focused on developing new treatments that result in biological repair and preclude the need to use non-degradable alloplastic implants. One of these approaches entails using tissue engineering methods to regenerate articular cartilage.³ However, the bearing surface of synovial joints is comprised of a layer of articular cartilage which is integrated with the underlying subchondral bone by mechanical interlocking. Recreation of this cartilage (soft tissue)-bone (hard tissue) interface is a major problem for bioengineering tissues for repair or replacement of joint surfaces.

Although a variety of methods have been proposed to repair osteochondral defects, the approach we have developed to bioengineer these articulating surfaces is to generate biphasic constructs composed of cartilage tissue overlying and integrated with a substrate that serves as the bone interfacing component (“osteochondral-type” biphasic constructs).⁴ We have developed a porous biodegradable ceramic substrate, composed of calcium polyphosphate (CPP), which has mechanical properties approximating cancellous bone and is suitable to use as a bone substitute material.⁵ To generate the biphasic construct articular chondrocytes are placed on the intended articulation surface of the CPP substrate and grown in culture for up to 8 weeks. As the cartilage forms *in vitro* the developing tissue fills the pores that open to the surface and in this way integrates with

the top portion of the substrate. Biphasic constructs (4 mm diameter by 6mm long) were implanted into focal defects created within sheep knees (trochlear groove). The implants successfully integrated with host tissues (bone and cartilage) with maintenance of the implant cartilage after 9 months *in vivo*, confirming the validity of our approach. The repair cartilage which had been subjected to the forces of normal activity matured significantly between 3 and 9 months as evidenced by the increase in mechanical properties, tissue thickness and collagen content. Bone grew into the pores of the CPP and there was no adverse reaction. In some regions the cartilage had fused with bone suggesting the possibility of recreating a natural subchondral interface.

The use of biphasic constructs to repair focal articular surface defects holds great promise. More importantly, after appropriate modification, they will also be suitable to use as a biological surface replacement which should prevent many of the problems associated with nondegradable prostheses.

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