28.P09
Development of macro/micro porous silk fibroin scaffolds with nano-sized calcium phosphate particles for bone tissue engineering

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Macro/micro porous silk scaffolds with nano-sized calcium phosphate (CaP) particles were developed for bone tissue engineering. Different amounts of nano-sized CaP particles 4, 8, 16 and 25% (CaP:silk fibroin, wt/wt) were generated into the highly concentrated aqueous silk fibroin solutions via an in-situ approach. Afterwards, the pure silk and silk/nano-CaP porous scaffolds were produced by a combination of salt-leaching/freeze-drying methods. Thermal gravimetric analysis results were able to demonstrated that the silk/nano-CaP scaffolds maintained 64–87% of incorporated CaP after salt-leaching. Dynamic mechanical analysis showed that storage modulus of the 16% formulation was significantly higher than all remaining groups. The porosity of silk/nano-CaP scaffolds assessed using Micro-Computed Tomography decreased from 79.8% to 63.6% with increasing CaP incorporated until 16%. By soaking the scaffolds in Simulated Body Fluid for 7 days, cauliflower-like apatite clusters were observed on the surface of both macro and micro pores of 16% and 25% formulations, which was not observed in 4 and 8% formulations. 16% silk/nano-CaP scaffolds were further chosen for in vitro cytotoxicity and biocompatibility assays. Both silk and 16% silk/nano-CaP scaffolds were non-cytotoxic and promoted cell adhesion and proliferation to a similar extent. These results indicated that the 16% silk/nano-CaP scaffolds could be a good candidate for bone tissue engineering.

28.P10
High strength silk protein scaffolds for bone repair

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Biomaterials for bone tissue regeneration represent a major focus in orthopedic research. In the U.S. alone, 1.3 million people undergo bone graft surgeries each year with skeletal defects either from accidents or disease. However, only a handful of polymeric biomaterials are utilized today due to their failure to address critical issues like compressive strength for load bearing bone grafts. A high compressive strength (~13 MPa hydrated state) polymeric bone composite material was developed based on silk protein-protein interfacial bonding. Towards this goal, a new hydrolysis method to generate silk microfibers with control of length was demonstrated. Micron sized silk fibers (10–600 μm) obtained were used as reinforcement in a compact fiber composite with tunable compressive strength, surface roughness and porosity. The developed 3D scaffold systems provided insight on the role of microfiber dimensions on mechanical properties and cell responses. A combination of surface roughness, porosity and scaffold stiffness favored human bone marrow derived mesenchymal stem cell (hMSC) differentiation towards bone-like tissue in vitro based on biochemical and gene expression for bone markers. Further, minimal in vivo immunomodulatory responses suggested compatibility of the fabricated silk-fiber high strength reinforced composite matrices for bone engineering applications.

28.P11
The hybrid silk fibroin scaffold with BMP2 loaded gelatin microspheres for effective bone regeneration

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The silk fibroin itself is a good candidate for tissue regeneration due to the high biocompability and slow degradation as well as robust mechanical properties. But without any biomolecular cues, the mesenchymal stem cell can lead to multiple lineage of differentiation on the pure homogenous silk fibroin scaffold .Therefore, loading the osteoinductive growth factor BMP2 into the scaffold is necessary for promoting the bone regeneration. While the direct loading faces the problem of retention in the long term, an indirect loading of BMP2 is conducted by imbedding the bmp2 binding gelatin microspheres into the silk scaffold via lyophilization. The hybrid silk fibroin scaffold not only presents more sustainable protein release profile, but also shows well maintained protein bioactivity. Besides, it showed improved compression properties as well as keeping the good interconnectivity. And it was also proven to have high cell viability and good cell attachment. The pig mesenchymal stem cell was used to study the osteogenic differentiation on this hybrid scaffold. And it showed better alizarin red staining results and higher genetic expression level of the osteogenic markers as compared to the direct bmp2 loaded homogenous silk scaffold. To be short, this hybrid bmp2 loaded silk fibroin scaffold has a great potential for effective bone regeneration.

28.P12
Silk fibroin for guided bone regeneration

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Silk fibroin (SF) is a natural protein polymer spun by silkworm Bombyx mori and used as a typical textile fiber and a surgical suture. Recently, cytocompatibility and tissue-compatibility of SF has been investigated and elucidated that there is no severe side effect to cell and tissue. The author examined the feasibility of SF as eardrum membrane and it is good for regeneration of eardrum with high efficiency. To expand the usability of SF, the author examined SF for guided bone regeneration. SF membrane with bioactive materials was pre-pared and examined the morphology, structural characteristics, and thermal properties. And then it was applied to white rabbit to evaluate bone formation. Histomorphology and removal torque were analyzed.

28.P13
Osteointegration of anterior cruciate ligament scaffolds fabricated of bombyx mori silk

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Various tissue engineering (TE) approaches are based on silk fibroin (SF) as scaffold material since its superior mechanical and biological properties compared to other materials. Especially in the field of ligament TE, SF scaffolds were extensively used. Surprisingly, there is still a lack of knowledge on the integration of SF scaffolds into bone. In a rabbit model, the ACL of the right leg was excised and the tibial and femoral bone tunnels were created with a 2.5 mm diameter drill bit.