Silk fibroin microparticle scaffolds: Microstructure design for bone tissue engineering

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DISCLOSURE:
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INTRODUCTION:
Bone defects caused by trauma, infection, or tumors require effective solutions for healing. There is an increased interest in using natural silk proteins in bone regeneration due to their favorable thermo-mechanical properties, ease of processability and excellent biocompatibility.
METHODS:
In this study we describe a method to prepare silk fibroin (SF) microparticles using a hexafluoroisopropanol-methanol solvent-coagulant combination. The microparticles are then fused together using regenerated silk fibroin solutions to form 3D microparticle regenerated silk fibroin (M-RSF) scaffolds. The scaffolds have been characterized for their morphological, mechanical and chemical properties. Further, the scaffolds have been tested *in vitro* using proteolytic enzymes to demonstrate the slow rate of biodegradation. The biological evaluation of the scaffolds was also performed using various *in vitro* assays by seeding osteoblasts on these scaffolds. Bone implantation studies were performed in the rabbit femur model (SCT/IAEC-184/ January/2016/89).
RESULTS:
SF microparticles obtained using this method are monodisperse, spherical, non-porous and have a predominant beta sheet conformation in SF protein. The M-RSF scaffolds have 40% bulk porosity as confirmed with X-ray tomography experiments. The scaffolds are characterized with interconnected pores having pore sizes >100 microns. The dry compression modulus >100 MPa, comparable to cancellous bone modulus, is one of the highest demonstrated moduli in the literature for pure SF scaffolds to date. Further, the scaffolds also exhibit high resistance to *in-vitro* proteolytic degradation retaining more than 90% of weight over a 7-day period when subjected to accelerated proteolytic degradation. *In vitro* studies underscored the role of M-RSF scaffolds in promoting proliferation and differentiation of osteoblast cells. Equally significant, *in vivo* studies demonstrate the scaffold's ability to stimulate new bone formation.
DISCUSSION:
SF microparticle scaffolds have mechanical and structural properties (porosity, pore size and compression modulus) comparable to cancellous bone and therefore promote proliferation of osteoblasts.
SIGNIFICANCE
The detailed characterization of M-RSF scaffolds showcases their potential as a compelling substitute for the repair of critical-sized bone defects. Further, advanced studies in animal models and clinical studies in patients are required to validate these observations.

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