Surface Modification of Polymeric Scaffolds for Bone Regeneration

Mohammed A. Yassin [1], Knut N. Leknes [1], Yang Sun [2], Zhe Xing [1], Anna Finne-Wistrand [2], Kamal Mustafa [1]

[1]Department of Clinical Dentistry, Faculty of Medicine, University of Bergen, Bergen, Norway
[2]Department of Fibre and Polymer Technology, KTH Royal Institute of Technology, Teknikringen, 56-58, SE 100-44, Stockholm, Sweden
Email: Mohammed.Yassin@uib.no

Abstract

Poly(L-lactide-co-ε-caprolactone) (poly(LLA-co-CL)) meets many of the requirements of a scaffolding material for bone tissue engineering, such as adequate biocompatibility, degradability, and tunable properties. However, poly(LLA-co-CL) scaffolding tends to be hydrophobic and does not favor cellular attachment and differentiation. The overall purpose of this research project was to improve the physical and chemical properties of poly(LLA-co-CL) scaffolds to enhance biological responses. The modifying effects were evaluated and characterized in vitro and in vivo. The hydrophilicity of the surfaces of poly(LLA-co-CL) scaffolding was increased, either by blending with Tween 80, or coating with nanodiamond particles (nDPs). Compared with pristine scaffolds, the modified poly(LLA-co-CL) scaffolds exhibited reduced albumin adsorption and significantly increased the seeding efficiency of bone marrow stromal stem cells (BMSC). Poly(LLA-co-CL)/3% Tween 80 scaffolds implanted subcutaneously in rats exhibited significantly increased mRNA expression of Runx2 and de novo bone formation. BMSC-seeded into poly(LLA-co-CL)/nDPs scaffolds were implanted into rat calvarial defects and live imaging at 12 weeks disclosed significantly increased osteogenic metabolic activity. Micro-computed tomography, confirmed by histological data, revealed a substantial increase in bone volume. Modifying the surface of poly(LLA-co-CL) scaffolds to improve hydrophilicity promotes osteoconductivity and bone regeneration. Further studies are needed to understand the immunogenic responses, because implantation of a biomaterial always initiates an inflammatory foreign body reaction. Moreover, the next generation scaffolding technique (3DF) may customize bio-inspired artificial extracellular matrices, incorporating optimal physical and chemical surface properties to improve stem cell support.