

University of Houston - Biomedical Engineering Seminar
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Systems Biology Guided Bone Regeneration



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Abstract

Engineering vascularized bone tissue for scaffolding and repairing remains a significant clinical problem. We are developing systems biology approaches to optimizing the temporal combinations of growth factor release from the engineering vessel grafted 3D scaffolds for in-vivo Bone regeneration (sBone system). 1) Using the classical BMP2/IGF1 dual-growth-factor temporal combination system as the biological model, our systems biology research, supported by coordinated experiments and multi-scale bio-assay and high-throughput screening, demonstrated the induction of Smad1/2 signaling pathways of MSCs by BMP2, which gradually remodels the expression pattern of Runx2 and Osx pathways, and thus sensitizes MSCs to the late IGF1 cue. We also engineered the BMP2/IGF1 dual controlled release bone scaffolds and proved the hypothesis remains valid for the bone regeneration in 3D macro-porous β -calcium phosphate (TCP) scaffolds. 2) To address the challenge of vascularization, we used a unique electrochemical cell detachment technique (EDT) to rapidly engineer a capillary-like vessel by detaching a human umbilical vein endothelial cell (HUVEC) layer from a solid rod to generate a hollow lumen with structural integrity, and transferred it to a centrally channeled, macro-porous VEGF-releasing TCP scaffold. 3) We recently have developed novel 3D multi-scale system models to study the effects of temporal combination of growth factors controlled by the gelatin micro-beads releasing system and the vascularization events from the pre-embedded HUVEC central channels of macro-porous TCP scaffolds and the effects on bone regeneration. Our preliminary studies indicate that the 3D multi-scale models can be potentially applied to predict vascularized bone regeneration with specific growth factor combinations and scaffold designs.

Biosketch

Professor Zhou is the Director of Center for Computational Systems Medicine at the UT Health Science Center. He received a B.S. degree from Lanzhou University, and earned both his M.S. and Ph.D. degrees from Beijing University. All of his degrees are in applied mathematics. From 1998 to 2004, he was a Postdoctoral Fellow with several universities including Tsinghua University, Beijing, University of Missouri-Columbia, Texas A&M University and Harvard Medical School. From 2005 to 2007, he was a faculty member with Brigham and Women's Hospital and Harvard University in Boston, MA. From 2007 to 2012, Zhou was the Chief of Bioinformatics and Professor of Radiology at Houston Methodist and Cornell Medical College in New York. Most recently, Zhou served as Professor, Chief of Bioinformatics and Director of Center for Bioinformatics and Systems Biology at Wake Forest University School of Medicine from 2012 to 2017.