Department of Civil Engineering and Engineering Mechanics

Columbia University

Live Allograft Bone Systems Showing How Human Bone Is a Very Organized Self-Repairing Tissue

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Biological tissues and in particular bone are characterised by a complex, often hierarchical and multi-functional architecture harbouring multiple cells' populations executing specific functions. Nature's constructions have optimal properties to efficiently respond to loading with minimal weight that cells adequately build upon detecting the proper mechanical stimuli. With increasing life expectancy, bone pathologies related to massive bone loss occur later in life and carry $5-$10 billion financial burden on the U.S. healthcare system. Human Haversian cortical bone heterogeneity results from continuous remodeling. Micro-damage are resorbed by osteoclasts cells before tubular lamellar structures called osteons are formed by osteoblast cells. Trapped osteoblasts further differentiate into mechano-sensitive osteocytes that bear 40 to 60 cytoplasmic processes extending into canaliculi to create a syncytial network with the neighboring cells with which they can transmit signals. However, bone healing ability declines with long term degeneration during aging, massive trauma or large tissue resections such as tumor removals. To promote bone growth in large defects, autograft bone is the gold standard repair but is limited by suitable tissue quantities and donor site morbidity. Successful techniques for massive tissue regeneration can often require addition of functional materials. Nonetheless, allograft bone can be stored but does not always perform as well as fresh autograft and the current tissue disinfection procedures such as supercritical carbon dioxide significantly modifies the tissue properties. Yet cleaned and decellularized tissue from a donor represents the ideal matrix for co-cultures of the recipient patient cells for fast tissue reintegration and functionalization. Because osteocytes regulate healthy bone turnover, it is essential to properly quantify by adequate experimental testing and modeling techniques the relationship between *in situ* mechanical stimulation and the cell biological response to design successful viable live allograft bone systems.

Dr. Elisa Budyn is Professor of Mechanical Engineering at Ecole Normale Superieure de Cachan in France. She is also Adjunct Associate Professor to the Departments of Mechanical Engineering and Oral Medicine and Diagnostic Sciences at the University of Illinois at Chicago. Elisa Budyn received her Ph.D. from Northwestern University in 2004, earned a one-year CNRS post-doctoral fellowship to study at CNRS LMSSMat Laboratory at Ecole Centrale Paris, after which she joined the UIC Mechanical Engineering Department in 2005 as Assistant Professor and ENS Cachan in 2013. Her research focuses on the design, implementation, experimental testing and numerical modeling of live allograft systems in particular for human bone tissue engineering. Thanks to close collaborations with scientists, physicists and medical surgeons, Dr. Budyn constructs intergrated numerical methods and experimental settings to investigate the nature of the mechanotransduction of human cells in connective and mineralized tissues. Her research also includes skin, cartilage, and the heart. Her research has been funded by NSF, CMMI, MOM, and BMMB programs, The US Air Force, CNRS and the Farman Institute.

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