Steering Biological Processes to Stimulate Bone Formation

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Bone formation is a physiological process required during embryogenesis, skeletal growth, skeletal remodelling, and bone healing following trauma. The latter often requires surgical intervention to fill bone voids and/or stabilize bone fractures. Increasingly frequently, such interventions include the installation of biomaterials, which need to perform in a reliable and effective manner. For bone substitute materials, this means that the biomaterial should interact with bone tissue to heal a bone defect within a limited time frame.

The biological performance of biomaterial-based bone substitute materials relates to bioactivity, osteoconductivity, and osteoinductivity. Bioactivity is the biomaterial property that refers to the possibility to achieve direct bone binding and apposition. Osteoconductivity extends on this by allowing growth of bone tissue along a biomaterial surface. Finally, osteoinductivity is the property that a biomaterial can induce *de novo* bone formation. It is important to emphasize that the gold standard in bone substitution is autologous bone, which possesses all these three performance criteria. Biomaterials developed for the purpose of bone substitution generally are bioactive and osteoconductive, but lack osteoinductive properties.

Biomaterial-based bone substitution has predominantly focused on the development of calcium phosphates (CaPs). An often-used justification for their (clinical) success is the fact that CaP in the form of hydroxyapatite is the mineral component of bone extracellular matrix. However, the true value of CaPs for bone substitution lies in their bioactive and osteoconductive properties and the options to render CaPs gradually degradable. Recently, few reports on osteoinductive properties of CaPs have been published, but the mechanism by which osteoinduction works remains elusive. In this presentation, the cellular basis for osteoinduction is reviewed and focus is placed on those biomaterial surface properties that stimulate *de novo* bone formation.