

DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

Bone tissue after injury or surgical intervention, has the ability to regenerate and return to its original state present before injury. This is also well known that bone can react to mechanical loading. By so-called functional adaptation, bone adjusts its structure and shape in response to the loads with different magnitudes and characters. This is possible because of activities of specialized cells playing roles of “mechanical sensors” (osteocytes) sending signals to other group of cells - “workers” - bone forming cells (osteoclasts) and cells responsible for tissue synthesis (osteoblasts). This well known facts suggest that with selected appropriate mechanical loading, one can optimize the surgical procedures (e.g. by choice of shape and type of endoprosthesis) as well as the medical procedures during bone healing and rehabilitation. The healing and regeneration of bone depend more on periodic mechanical loading compared to constant in time because osteocytes are sensitive to fluid flow excited by the deformation of surrounding porous tissue. However, in spite of the fact that this is already known for many years this effect is not completely explained and described.

Mathematical modeling consists on formulation of mathematical formulas describing phenomena under consideration. When mathematical model is available, that is – when all of the mathematical relations taking into account links between the most important processes involved in healing and regeneration are written, one can implement them into a computer program and next perform the numerical simulations to forecast healing effects and to explain mutual relations between the selected parameters, and their impact in the process. This consideration suggests the main goal of the project.

Previous experience of the applicant has shown that mathematical models, although being simplistic compared to real biomechanical processes occurring in the living organism, can be successfully utilized to study and explain some aspects of bone regeneration and healing. The aim of the proposed research is to develop a mathematical model that better describes the bone healing process than previously proposed models, including into account the periodic loading; numerical implementation of mathematical formulas and computer simulations to verify the proposed relationships; and to choose model parameters. Such a model should be able to reveal the cellular signaling, the variations of the structure of the bone and bone substitute material associated with their resorption and synthesis of tissue, the effects of vibration amplitude, frequency harmonic loading and the starting time and duration of the treatment on the healing process and results. The proposed mathematical relationships will be implemented in a computer program using the finite element method, then numerical simulations will be performed for investigation of different possible scenarios during bone healing and verification of the theoretical model. In order to estimate some structural parameters as for example porosity and permeability necessary to perform calculations some laboratory tests are planned with samples of selected bone substitute materials. These materials often serve as a media necessary to fill possible cavities and gaps in bones during orthopedic surgeries.