MODELING OF BONE – BIORESORBABLE GRAFT INTERACTION

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1. Introduction

In recent orthopedic practice bioresorbable materials get more and more attention in bridging bony defects and filling bony losses. The application of such materials is associated with important advantages, among the others – it allows to avoid the usage of autogenic and allogenic implants associated with a risk of graft contamination and possibility of rejection as well as results in reduction of surgery invasiveness compared to cases of autogenic implants. Mathematical and computational models of effects present after graft implantation might be used in many situations, among the others – in surgery planning, in optimization of graft material characteristics, and in planning therapy after operation.

2. Modeling of tissue evolution in presence of resorbable material

Changes in bone after bioresorbable graft implantation are complex and not entirely known yet. Generally speaking there exist two major effects interacting with each other namely, tissue formation and remodeling and resorption of implanted graft. The interaction between them is of biological and mechanical nature. This is well known fact that bone adapts its micro structure and shape to variable in time mechanical loading what is known as functional adaptation. On the other hand the resorption of graft has sometimes significant influence in overall or local bone mechanical characteristics what evidently affects the activities of cells playing a fundamental role in the process of bone healing and adaptation after surgery. However graft resorption is not completely independent on its environment, it is also dependent of cells activity. Therefore these two effects can not be considered separately and models including both are needed.

3. Results

Mathematical description of simultaneous formation and remodeling of bone and resorption of bioresorbable graft was proposed. In this model three groups of bone cells are considered, one playing role of mechanical sensors, second responsible for tissue formation and the last for tissue resorption. These two simultaneous processes are affected by the third process - graft resorption which depends to some extent on cells activities. To derive necessary mathematical relations an approach proposed earlier by the author based on the hypothesis of optimal response of bone was used , see e.g. Lekszycki {1, 2]. They form nonlinear problem defined by a set of partial differential equations, integral inequalities, and algebraic inequalities and equations. It can be only solved numerically by incorporating finite element method to determine an actual state of system under examination with bone adaptation relations and graft resorption relations in one subroutine. This way the simulations of the process in bone after surgery are possible. Selected results of computer calculations will be presented to illustrate the application of proposed model in solution of practical

problems. Additional works are necessary and are being performed to compare effects of calculations with the clinical observations and results of experimental investigations.

6. References

[1] T. Lekszycki (1999). Optimality conditions in modeling of bone adaptation phenomenon, *J. Theoret. Appl. Mech.*, **37**, 3, 148-167

[2] T. Lekszycki (2002), Modelling of bone adaptation based on an optimal response hypothesis, *Meccanica*, **37,** 343 - 354