15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Abstract ID-232

BONE REMODELLING ANALYSIS OF THE TIBIA AFTER A TOTAL KNEE ARTHROPLASTY

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Keywords: total knee artroplasty, metaphyseal sleeves, stress shielding, bone remodelling

Summary: Total Knee Arthroplasty is one of the possible solution for osteoarthritis and other pathologies treatment. However, there are complications that can compromise its success. The stress shielding effect generated by the implant induce a reduction in the bone mass which can contribute to the prosthetic failure, more frequently in the tibial side. The tibial components currently used include the metallic tibial tray, the polyethylene insert and the stem. The stem can take different configurations depending on the bone condition. It can be the standard stem, normally used for primary surgeries, or longer stems. In some cases, to increase stability of the implant, metaphyseal sleeves can be added to tibial implant configuration. However, the option for different support systems changes the stress state on bone and the stress shielding effect can be more severe. Thus, the objective of this study is to compare the stress shielding effect for all these options, in order to have a pre-clinical evaluation of their biomechanical performance.

For this purpose, in this study the bone remodeling process is analyzed after a total knee arthroplasty, using six different implant configurations, which include three different stem lengths, with or without the presence of a metaphyseal sleeve. First, a three-dimensional model of the intact tibia was obtained from CT images and the bone density at each site of the tibia was defined using a computational bone remodelling model. Then a virtual surgery was performed using prosthesis components modelled in Solidworks and the bone-remodeling model was applied again to evaluate how the bone density evolves in the presence of the implant. The model used in this work takes into account both structural stiffness and the metabolic cost of bone maintenance. The applied loads included the knee joint reaction forces and muscle forces at six different time instances of the walking gait.

Results show that the standard stem leads to relatively low values of bone mass change, whereas long stems lead to bone apposition in the diaphysis and significant bone resorption in the proximal regions, and the metaphyseal sleeve increased the values of proximal bone resorption.