Periprosthetic stress shielding in patello-femoral arthroplasty: a numerical analysis

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Abstract: Total knee replacement gives proven good results for isolated patello-femoral osteoarthritis, but patello-femoral arthroplasty may be more appropriate because only the joint compartment is replaced. Although the femoral component of a patello-femoral prosthesis is smaller than in total knee arthroplasty, it is unknown whether strain-adaptive periprosthetic bone remodeling occurs following patello-femoral arthroplasty. The aim of the study was to evaluate and compare the stress shielding effect of prosthetic replacement with Finite Element (FE) modeling. Four FE models were developed to investigate the effects of different patellofemoral replacement designs; we compared the stress shielding effect in the distal femur between a physiological model of knee, the Richards type II patellofemoral prosthesis, the Journey PFJ prosthesis, and the Genesis II total knee prosthesis. The geometry of the knee joint was obtained from a MRI of a patient. Von Mises stress was evaluated in the same regions of interest as in the experimental analysis, during a loaded squat until 120° of flexion, similar to previous experimental tests performed on knee kinematics simulators. During knee flexion the Journey PFJ has a similar trend of the physiological knee; the Richards II PFJ has higher stress shielding than the other PFJ model and in the Genesis II TKA the stress shielding is higher compared to the PFA models. The results agree with experimental DXA literature results; in particular they demonstrated that, during knee flexion, the magnitude of the Von Mises stress behind the anterior flange was about the same for the physiological model and for the Journey PFJ but smaller for the Richards II. This stress shielding effect of the Richards II was most obvious around 90 degrees of flexion. This phenomenon can possibly be explained by the particular design features of the Richards II. In the proximal region of the bone the values of the Von Mises stress were about the same magnitude for the physiological model and for both patello-femoral prostheses and also these findings are in agreement with the experimental DXA outcome.

Keywords: Biomedics, Implantable Medical Device, Patellofemoral joint; Stress shielding; Squat movement

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