Asymptotic modelling of tibio-femoral contact for multibody dynamic simulations of the human knee joint

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Multibody dynamic simulations of joints require modelling the distributed internal forces generated by articular contact. It is believed that namely dynamic and impact patterns of the contact pressures play an important role in the development and progression of knee joint osteoarthritis. Thus, multibody dynamic models of the knee joint capable of predicting contact stresses would be useful for studying the mechanical aspects of this joint degenerative disease.

A multibody knee contact modelling methodology [1,2] should include the implementation of an efficient mathematical model for calculating contact pressures. A number of musculoskeletal models of the knee joint employ different forms of the elastic Winkler foundation model [3]. It is known [4] that this model is appropriate for describing the stress-deformation behavior of thin compressible elastic coating layers, and it fails to represent contact interaction of incompressible coatings. At the same time, it was shown [5] that a biphasic cartilage layer under distributed normal forces behaves like a bonded thin incompressible elastic layer.

A new methodology for modelling tibio-femoral contact presented in this study is based on the recently developed asymptotic model of frictionless elliptical contact interaction between thin viscoelastic cartilage layers [6]. The approach requires use of the smooth contact surface geometry and efficient contact points detection methods. The normal contact forces are determined analytically based on the exact solution for elliptical contact between thin viscoelastic cartilage layers.

References

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