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# Coupled multi-body dynamics / Reynolds equation method with application to transient elastohydrodynamic lubrication simulation of hip arthroplasties

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The number of total hip replacement operations increases worldwide and in particular an increase in the number of young patients requiring total hip replacement has recently been seen. Therefore, the expected lifetime of the prostheses is to increase. Wear has a crucial role on longevity and performance of total hip arthroplasties. The science and technology of wear, friction and lubrication of interacting surfaces in relative motion is the subject of tribology. It is known that friction opposes relative motion of two surfaces sliding with respect to each other. As a result, the corresponding surfaces undergo material loss due to wear, which eventually leads to the system failure. Lubricant is added between contacting surfaces to facilitate relative motion and prevent surfaces to damage. The present study aims to develop a computational model to investigate tribology of lubricated hip implants. A coupled model of multibody dynamics and fluid dynamics with application to hip arthroplasties while taking into account both squeeze-film action and wedge-film action under normal walking condition is developed. According to in vivo loadings and motion obtained by means of instrumented hip implants, a cross-section is introduced to isolate the articulation of the cup and femoral head. The acetabular cup is assumed stationary while the femoral head is free to move and provide us with required physiological motion. The motion equations of the system is derived based upon multibody dynamics methodlogy while synovial fluid is formulated using Reynolds equation. The finite difference method is utilized to discretize the governing equation of lubricant and multi-grid method decreases computational time taken to obtain results using Gauss-Seidel relaxation scheme. Fluid-structure interaction is treated using a two-way method embedded in an adaptive Runge-Kutta-Fehlberg method solving nonlinear dynamics equations of the coupled system. A demonstrative example is also presented to show the capability of the developed model. Moreover, the system parameters, e.g clearance and hip size and fluid property are assessed. It is shown that the maximum pressure of synovial fluid significantly decreases when the elasticity of hip components is taken into account. Decreasing clearance size decreases fluid pressure observed onto the hip bearing surfaces. Although maximum fluid pressure takes place during the stance phase, minimum film thickness occurs during the swing phase. It is shown that the maximum fluid pressure is obtained in the first walking cycle, which decreases after a few gait cycles.