Influence of Meniscectomy and Meniscus Replacement on the Stress Distribution in Human Knee Joint

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Abstract: Studying the mechanics of the knee joint has direct implications in understanding the state of human health and disease and can aid in treatment of injuries. In this work, we developed an axisymmetric model of the human knee joint using finite element method, which consisted of separate parts representing tibia, meniscus and femoral and tibial articular cartilages. The articular cartilages were modeled as three separate layers with different material characteristics; top superficial layer, middle layer and calcified layer. The biphasic characteristic of both meniscus and cartilage layers were included in the computational model. The developed model was employed to investigate several aspects of mechanical response of the knee joint under external loading associated with the standing posture. Specifically, we studied the role of the material characteristic of the articular cartilage and meniscus on the distribution of the shear stresses in the healthy knee joint and the knee joint after meniscectomy. We further employed the proposed computational model to study the mechanics of the knee joint with an artificial meniscus. Our calculations suggested an optimal elastic modulus of about 110 MPa for the artificial meniscus which was modeled as a linear isotropic material. The suggested optimum stiffness of the artificial meniscus corresponds to the stiffness of the physiological meniscus in the circumferential direction.