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A Transversely Hyperelastic Shell Element

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Abstract

A degenerated shell theory is developed to model soft tissue structures such as ligaments and tendons in the finite element model of the human knee. The constitutive behavior of these materials can be accurately modeled within the framework of incompressible, transversely isotropic hyperelasticity. The shell element has been implemented in NIKE3D, is valid for large strains and incorporates incompressibility in a novel fashion that obviates the use of penalty formulations while maintaining zero normal stress. A transversely isotropic hyperelastic constitutive law developed specifically for tissue modeling is presented and implemented in the shell formulation. Special provisions are made to incorporate reduced shear strain fields for preventing shear locking of lower order shell elements. Results indicate that the formulation is both accurate and efficient for modeling hyperelastic shell structures.

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