Successful mitral valve repair is dependent upon a full understanding of normal and abnormal mitral valve anatomy and function. Computational analysis is one such method that can be applied to simulate mitral valve function in order to analyze the roles of individual components and evaluate proposed surgical repair. We developed the first three-dimensional finite element computer model of the mitral valve including leaflets and chordae tendineae; however, one critical aspect that has been missing until the last few years was the evaluation of fluid flow, as coupled to the function of the mitral valve structure. Presented here are our latest results for normal function and specific pathological changes using a fluid-structure interaction model. Normal valve function was first assessed, followed by pathological material changes in collagen fiber volume fraction, fiber stiffness, fiber splay and isotropic stiffness. Leaflet and chordal stress and strain and papillary muscle force were determined. In addition, transmirtal flow, time to leaflet closure and heart valve sound were assessed. Model predictions in the normal state agreed well with a wide range of available in vivo and in vitro data. Further, pathological material changes that preserved the anisotropy of the valve leaflets were found to preserve valve function. By contrast, material changes that altered the anisotropy of the valve were found to profoundly alter valve function. The addition of blood flow and an experimentally driven microstructural description of mitral tissue represent significant advances in computational studies of the mitral valve, which allow further insight to be gained. This work is another building block in the foundation of a computational framework to aid in the refinement and development of a truly non-invasive diagnostic evaluation of the mitral valve. Ultimately, it represents the basis for simulation of surgical repair of pathological valves in a clinical and educational setting.

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