The close relationship between the mechanical properties of biological cells, namely, elasticity, viscosity, and the state of its disease condition has been widely investigated using atomic force microscopy (AFM). In this study, computational simulation of the AFM indentation is carried out using a finite element (FE) model of an adherent cell. A parametric evaluation of the material properties of the cellular components on the viscoelastic, stress-relaxation response during AFM indentation is performed. In addition, the loading rate, the size of the nucleus, and the geometry of the cell are varied. From the present study, it is found that when comparing the material properties derived from experimental force-deflection curves, the influence of loading rates should be accommodated. It also provides a framework that can quantify the variation of the mechanical property with various stages of malignancy of the cancer cell, a potential procedure for cancer diagnosis.