Two-dimensional finite element simulation of fracture and fatigue behaviours of alumina microstructures for hip prosthesis

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This paper describes a two-dimensional (2D) finite element simulation for fracture and fatigue behaviours of pure alumina microstructures such as those found at hip prostheses. Finite element models are developed using actual Al2O3 microstructures and a bilinear cohesive zone law. Simulation conditions are similar to those found at a slip zone in a dry contact between a femoral head and an acetabular cup of hip prosthesis. Contact stresses are imposed to generate cracks in the models. Magnitudes of imposed stresses are higher than those found at the microscopic scale. Effects of microstructures and contact stresses are investigated in terms of crack formation. In addition, fatigue behaviour of the microstructure is determined by performing simulations under cyclic loading conditions. It is shown that crack density observed in a microstructure increases with increasing magnitude of applied contact stress. Moreover, crack density increases linearly with respect to the number of fatigue cycles within a given contact stress range. Meanwhile, as applied contact stress increases, number of cycles to failure decreases gradually. Finally, this proposed finite element simulation offers an effective method for identifying fracture and fatigue behaviours of a microstructure provided that microstructure images are available.

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