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Finite element modeling of the piston-on-three-balls testing of zirconia ceramics with two distinct ZrO2-tetragonal fractions

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In this work, the flexural strength of zirconia ceramics containing different Y_2O_3 contents (3mol.% or 5mol.%) was evaluated using piston-on-three-balls testing using the finite element method. Dense zirconia specimens were sintered and characterized by X-ray diffraction, scanning electron microscopy, relative density and mechanical testing. A numerical model is proposed to evaluate the biaxial flexural strength using the finite element code ABAQUS. The experimental results point out full densification on sintered samples with different tetragonal/cubic ZrO_2 ratio, and different grain size distributions. Mechanical characterization of sintered samples indicated Young's modulus of 192 GPa and 198 GPa for ZrO_2 doped with 3mol.% and 5mol.% respectively, along with flexural strength of 1200MPa and 510 MPa. Rietveld refinement revealed 80% and 20% tetragonal phase for ZrO_2 doped with 3mol.% and 5mol.%, respectively. These results indicate that the increase of tetragonal phase leads to an increase between the experimental and numerical predictions of the biaxial flexural strength. Specimens with 80% of tetragonal phase presented 7% of deviation from the experimental value and samples containing 20% of tetragonal phase provided only 1%. This reveals that an increase of the fraction of tetragonal phase, together with its respective transformation during the fracture, must be considered in the finite element simulations of ceramics (monolithic or composite).