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Performance Assessment of Speed-Sintered Multigrade Monolithic Zirconia Ceramics

S. Čokić[2], B. Van Meerbeek[2], J. Vleugels[1], F. Zhang[2, 1]
[1]Department of Materials Engineering (MTM), KU Leuven, Leuven, Belgium, [2]BIOMAT - Department of Oral Health Sciences, KU Leuven, Leuven, Belgium

Objectives To evaluate the performance of speed-sintered multigrade monolithic zirconia through a comprehensive analysis of its microstructure, optical and mechanical properties.
Methods Speed-sintered multigrade 4Y/5Y-PSZ ZirCAD MT Multi (Ivoclar) (total thermal cycle: 60 min) was compared to 4Y-PSZ Katana HT (total thermal cycle/sintering time/dwell temperature: 90min/30min/1515 °C) and 5Y-PSZ Katana STML (Kuraray Noritake) (90min/30 min/1560 °C). Density was determined according to the Archimedes principle; chemical composition was determined using X-ray fluorescence; phase composition was characterized using X-ray diffraction; grain size was measured using scanning electron microscopy; Translucency Parameter was measured with a spectrophotometer. Vickers hardness, indentation fracture toughness and biaxial strength were also assessed. Layers of polychromatic zirconia was evaluated by light microscopy and nanoSEM-EDX. Statistical analysis involved one-way ANOVA and post-hoc Tukey's HSD test (α=0.05).
Results All zirconia grades showed similar density (≈6.02±0.01 g/cm^3). ZirCAD MT Multi was characterized by three distinct layers, each with different phase compositions. 5Y-PSZ layer contained the highest amount of Y_2O_3 in the remaining tetragonal ZrO_2 phases (5.4 mol%) compared the transition and the 4Y-PSZ layer (4.6 mol% and 3.5 mol%, respectively). The grain size between the 4Y-PSZ layer and Katana HT was similar (≈0.3 µm), while the 5Y-PSZ layer had a smaller grain size (0.9 µm) compared to Katana STML (1.2 µm). Transition layer revealed the presence of agglomerates consisting of small grains, higher Y_2O_3 content and presence of Er. No statistical difference in hardness was observed. Toughness of 4Y-PSZ layer (3.7 MPa m$^{1/2}$) was significantly higher compared to Katana HT (3.2 MPa m$^{1/2}$). There was no statistical difference in TP between 4Y-PSZ and 5Y-PSZ layers and Katana HT and STML, respectively. ZirCAD Multi MT showed significantly lower biaxial strength compared to Katana HT (548.6±63.9), but demonstrated the highest mechanical reliability (m=11).
Conclusions Multigrade 4Y/5Y-PSZ zirconia showed similar density, microstructure, translucency and hardness compared to monograde zirconia. However, further studies should focus on improvement of flexural strength of speed-sintered multigrade zirconia.