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Surface Analysis of Additively Manufactured Dental Zirconia Ceramic

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Objectives Differences in three-dimensional printing (3DP) technologies for dental zirconia ceramics are also reflected in final surface quality that significantly influences adhesion of bacteria in oral cavity, as well as adhesion of dental composite cements and translucency of zirconia ceramics. This study aimed to evaluate surface properties of dental zirconia ceramics manufactured using various 3DP technologies and traditional computer-assisted (CAD-CAM) milling.
Methods Disc-shaped specimens were prepared using two different 3DP technologies: material extrusion (MEX, Prusa i3 MK3S, Prusa, Czech Republic) and vat photopolymerization (VPP, CeraFab 7500, Lithoz, Austria), along with CAD-CAM milling. Specimens were treated with air-particle abrasion alumina particles (APA, 50 μm Al_2O_3). Surface topography was analyzed using scanning electron microscopy (SEM). Surface roughness was measured using optical profilometry. Wettability and capillarity were assessed using contact angle measurement and capillary rise method, respectively. Crystallographic composition of specimens was evaluated by X-ray diffractometry (XRD). Bond strength to composite cements was determined by shear bond strength test (SBS, n=12/group). Type of fracture was evaluated using stereomicroscopy. One-way ANOVA and t-test were used to determine differences among SBS groups ($P<0.05$).
Results SEM analysis revealed that VPP and CAD-CAM-milled specimens exhibited surfaces with fewer defects compared to those produced by MEX. Optical profilometry confirmed these observations, showing the lowest average surface roughness in VPP and CAD-CAM groups compared to MEX group. APA treatment resulted in lower contact angles for all manufacturing groups. Enhanced capillarity was observed in MEX group. XRD analysis did not reveal significant differences in crystallographic phases among the groups. APA enhanced resin-zirconia SBS compared to no treatment, although no differences were observed among the manufacturing groups.
Conclusions The study demonstrates that VPP and CAD-CAM milling produce zirconia ceramics with superior surface quality compared to MEX, exhibiting fewer defects and lower roughness, which are essential for improved dental restoration performance.