Innovations in Zirconia Ceramics for Dental Restoration through Additive Manufacturing

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Ceramic-based dental materials continue to evolve, driven by the demand for durability, aesthetics, and biocompatibility. This research presents the development of a locally produced novel 3 mol% yttria-stabilized zirconia (3YSZ) block for dental restoration. Through colloidal processing, slip casting, and optimized sintering, a homogenous microstructure with improved mechanical properties was achieved. Recent research highlights the influence of nanoparticle size, surface modification, and primer treatments on shear bond strength, alongside microstructural characterization using FESEM, TEM, and XRD. The machinability of zirconia blocks into crown geometries, combined with finite element analysis of veneering techniques, provides insights into performance under functional loading. Current findings demonstrate promising wear resistance, bond strength, and clinical adaptability of the novel zirconia system. Looking forward, scaling to commercial-sized blocks and integrating extrusion-based additive manufacturing, particularly Direct Ink Writing (DIW), will further advance personalized dental restorations, bridging material innovation with digital dentistry for the next generation of patient-specific solutions.