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Fatigue Strength of Cobalt-Chromium Alloys Fabricated by Additive Manufacturing

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Objectives Removable partial denture (RPD) frameworks made of cobalt-chromium (Co-Cr) alloys by additive manufacturing (AM) have been used. However, the influence of the fabrication techniques on the fatigue strength of Co-Cr alloys remains to be fully elucidated. The purpose of this study was to evaluate the fatigue strength of Co-Cr alloys used in RPD framework fabricated by AM compared to conventional casting.
Methods Co-Cr alloy specimens were fabricated under the following conditions (each condition: N=10); AM was fabricated using a selective laser melting machine (LUMEX Avance-25) in powder bed fusion, and CAST was cast using a high-frequency centrifugal casting machine (Denko Auto Sensor MD-201). Static and dynamic flexural strengths were measured in both a universal material testing machine (AG-I 20kN) and fatigue testing machine (EHF-F05). The cyclic fatigue test was performed by the staircase method in water at 37 degrees, with a load of 10^6 cycles and 10 Hz. After mechanical test, the specimens were observed under a scanning electron microscope (SEM; SU6600). The flexural strengths between experimental conditions were statistically analyzed using Mann-Whitney's U test (α=0.05).
Results The static flexural strengths for AM and CAST were 1472±41 MPa and 1173±53 MPa, respectively, and a statistically significant difference was observed between the two conditions (p<0.05). The fatigue strength for AM and CAST was 54±8% and 42±4% compared to the static flexural strength, respectively. The CAST specimens after tests were observed to cracks and there were grains in the crack, indicating an intergranular fracture was occurred, while the AM were observed a striation after fatigue test. As AM in additive manufacturing provides superior flexural strength due to strong grain boundary bonds.
Conclusions Co-Cr alloy fabricated by AM showed higher static flexural and fatigue strengths than casting one, suggesting that the AM-fabricated framework could have more durability.