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Mechanical Properties of Additively Manufactured Zirconia Depending on Build Orientation, Post-Processing, and Thermocycling

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Objectives The study aimed to evaluate the effect of build orientation, post-processing, and thermocycling (TC) on the mechanical properties of additively manufactured (AM) zirconia compared with those of subtractively manufactured (SM) zirconia.

Methods Bar- (17×4×1.5 mm) and disc-shaped (10×2 mm) STL files were used to fabricate AM (3-YTZP) and SM (3-YTZP and 4-YTZP) zirconia specimens. AM specimens were printed using 3 different build orientations (horizontal, tilted, and vertical), and the specimens were post-processed either using 1-stage (debinding combined with sintering) or 2-stage processes (debinding, cooling, and sintering) (n=24 bars/12 discs per subgroup). The discs were polished. Half of the bars and all discs were subjected to thermocycling (10.000 cycles, 5-55°C). Flexural strength (FS) was measured before and after TC, and VH was measured before and after polishing, and after TC.

Results A significant interaction was found between material type and thermocycling for the FS and VH (p<.001). Before TC, SM-3YTZP had a higher FS than other groups (p<.001), except for SM-4YTZ (p=.084). Before TC, tilted 1- and 2-stage AM zirconia had lower FS than vertical 1-stage AM zirconia (p≤.016), whereas there was no difference among other pairs (p>.054). After TC, vertical 2-stage AM zirconia had lower FS than other groups (p<.003), except for vertical 1-stage AM zirconia (p>.99). After polishing, the VH of tilted and vertical AM zirconia increased (p<.012). All groups had similar VH after polishing (p>.108) and after TC (p>.818).

Conclusions All groups had FS higher than that required for single-unit monolithic ceramic prostheses (ISO6872:2015; 300 MPa), regardless of TC. The effect of TC on FS varied depending on the material type, build orientation, and post-processing. Before TC, all AM zirconia groups had lower FS than SM-3YTZP. Polishing increased the VH of vertical and tilted samples. After polishing, build orientation, material type, and TC had no significant effect on the VH.