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*Abstract*

# Sterilization Effects on Dimensional Accuracy of 3D-Printed Carbon Fiber-Reinforced Nylon

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Ensuring dimensional stability of additively manufactured (AM) medical components during sterilization is a critical yet understudied challenge. This study investigates the influence of geometry, continuous carbon fiber (CCF) reinforcement, and sterilization methods on the dimensional accuracy of fused filament fabricated (FFF) CCF reinforced nylon composites. 40 specimens of standard (ASTM D3039) and non-standard geometries were produced using Onyx, both with and without CCF reinforcement. Printed samples were subjected to ethanol disinfection or steam autoclaving under ISO guidelines. MicroCT imaging was conducted before and after sterilization, and 3D geometric analysis was performed.

Sterilization type did not affect surface deviation post treatment ($p = 0.1643$), but deviations were primarily influenced by part geometry ($p < 0.001$) and CCF reinforcement ($p = 0.0031$). Non-standard geometries with concentric fiber paths demonstrated significantly greater resistance to warping compared to standard rectilinear patterns ($p < 0.001$). Standard geometry without CCF reinforcement showed the highest deviations of all tested groups with a max deviation of 0.5 mm on average. Void fraction analysis further indicated that both, geometry and CCF reinforcement, contribute to porosity variations ($p = 0.0038$; $p = 0.0044$), with reinforced components displaying marginally higher (> 1%) void fractions.

These findings emphasize that optimizing print resolution, reinforcement strategies, and geometric design can help define production guidelines for 3D-printed composite implants compatible with sterilization protocols in healthcare. Future research should explore alternative sterilization techniques and advanced composite materials to further refine the applicability of AM in medical device manufacturing.

**AUTHOR'S STATEMENT**

The complete study is under review in Nature Scientific Reports journal. Conflict of interest: A. Heede and J. Milite are employees of Stryker Trauma GmbH. This was a research project conducted solely for academic purposes and did not provide any direct benefit to Stryker.

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