Biomechanical Testing of 3D-Printed Implants for the Fixation of OTA Type B Ankle Fractures

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Purpose: 3D printing is an affordable manufacturing option that offers many advantages for healthcare delivery. The purpose of this study was to evaluate the use of 3D-printed one-third tubular plates compared to standard manufactured plates for the fixation of OTA type B ankle fractures.

Methods: Carbon-fiber–reinforced polyetheretherketone one-third tubular plates were designed and printed using Fused Deposition Modeling printers by the study authors. A cadaveric biomechanical comparison between fractures stabilized using 3D-printed plates and those stabilized using standard manufactured plates was performed. Match-paired specimens underwent axial cyclic loading and torsional load to failure defined as 2 mm of fracture displacement. A 4-point bend test was performed. Generalized estimating equations were used to compare results.

Results: Ten match-paired specimens underwent mechanical testing. All specimens survived 100,000 cycles loaded to 875N. Torque at failure did not significantly differ between groups ($p = 0.14$). During torsional load to failure, all 10 specimens (100%) with the standard plate failed because of screw pullout. Five specimens (50%) with the 3D plate failed because of screw pullout, and five (50%) failed because of plate fracture. Eight plates (four 3D, four standard) underwent a 4-point bending test. Stiffness was significantly lower in the 3D plate ($p<0.0001$). The intraclass correlation coefficient was 0.98 for the 3D-printed plates and 0.96 for the standard manufactured plates demonstrating high consistency within groups.

Conclusion: These results demonstrate that fixation constructs composed of 3D-printed one-third tubular plates performed similarly to standard manufactured devices in simulated clinical tests despite differences in mechanical properties. There was no significant difference between the two groups with regard to performance during cyclic axial load or torsional force to failure, indicating that there may be a role for 3D-printed devices such as these in clinical practice. Furthermore, the 3D-printed devices were able to be reliably reproduced with each plate performing similarly. The ultimate stiffness and mode of failure, however, were different. As 3D printing becomes more prevalent, it is essential to understand their design, their potential benefits, and how they differ from standard manufacturing in order to optimize function and prevent complications.