



Post-yielding fracture mechanics of 3D printed polymer-based orthopedic cortical screws

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Abstract

The internal fixation of a fractured bone is generally achieved with bone screws during most orthopedic surgeries. Biodegradable screws have not received as much attention as they deserve. Biodegradable screws reduce the stress-shielding effect, screw failure, complex, painful revision surgery for screw extraction. The vital focus of the present research is to fabricate cortical bone screws using polylactic acid (PLA) by fused deposition modeling technology. The PLA cortical screws were manufactured with different infill patterns (triangular, honeycomb, grid, and concentric), keeping other parameters constant using three-dimensional printing. The mechanical behavior and fracture mechanism of different patterned cortical screws were observed based on compression testing and tensile testing of screws. Scanning electron microscopy (SEM) observed the surface topographical features, fracture behavior, and microstructure characterization of different patterned polymeric cortical screws were observed using SEM. Based on the SEM micrographs, mechanical characterization of compression and tensile testing shows the stress, fractures and fatigue cracks propagation at the bone screw interfaces by fractures copy. Moreover, it was observed that the fracture mechanism of ductile to brittle fracture was observed with variation in the infill pattern of the bone screw. The outcomes revealed that the cortical screw with honeycomb infill pattern has the highest compressive and tensile strength than other infill patterns. Honeycomb structured cortical screws have approximately 17% higher compressive strength and 30% higher tensile strength than the triangular patterned cortical screw due to higher bonding surface area at the intercalated layers.

KEYWORDS

compressive strength, cortical screw, fracture mechanism, fused deposition modeling, tensile strength

1 | INTRODUCTION

A bone fracture may happen due to accidents, stress fracture and aging. The treatment of fractured bone is repaired with the bone screws as bone screws are efficient means of

securing and retaining the accurate position of fracture parts for early mobilization and early union.^[1,2] The standard gold biomaterials for bone screws are metals like stainless steel, titanium, and cobalt–chromium. These metallic biomaterials cause bone screw related complications like

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