

# Surface Treatment of 3D Printed Porous Ti6Al4V Implants by Ultraviolet

## Photofunctionalization for Improved Osseointegration

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### Introduction:

Three-dimensional (3D) printed porous Ti6Al4V implants are widely used for bone defect reconstruction due to their mechanical compatibility and porous architecture conducive to bone ingrowth. However, the bioinert nature and carbon contamination of titanium surfaces significantly limit osseointegration. Traditional surface modification methods like coatings or BMP-2 incorporation have limitations including high cost and invasiveness. Ultraviolet (UV) photofunctionalization has emerged as a simple, low-cost method to restore surface bioactivity without altering the implant's morphology, but its efficacy in 3D porous structures remained unverified due to UV penetration limitations.

### Methods:

An omnidirectional UV radiator was designed using 270 nm and 365 nm UV LED beads to uniformly irradiate porous Ti6Al4V scaffolds. Surface characterization was conducted using SEM, EDS, XPS, and XRD. In vitro assays assessed wettability, carbon contamination, cytocompatibility, and ALP activity using rat BMSCs. In vivo osseointegration was evaluated in a rabbit femoral condyle defect model at 8 weeks, via micro-CT, histology (BI, BICR, mineralized/osteoid ratio), and push-out tests.

### Results:

UV treatment significantly improved scaffold hydrophilicity (contact angle: 90.1 degrees vs. 60.3 degrees), decreased surface carbon content (C-C: 87.45% vs. 81.72%), and increased ALP activity (0.68±0.08 vs. 1.47±0.25 U/mg). In vivo, UV-treated implants showed enhanced bone ingrowth (BI: 22.16% vs. 13.84%), bone-implant contact (BICR: 39.76% vs. 14.66%), and mineralized bone ratio (79.86% vs. 43.66%) without altering mechanical strength. Push-out force increased from 304.7 N to 450.5 N after UV treatment. Fluorescent labeling indicated earlier osteogenesis onset.

### Discussion:

UV photofunctionalization using an omnidirectional radiator provides a practical strategy for restoring and enhancing the surface bioactivity of 3D-printed Ti6Al4V implants. It avoids the drawbacks of chemical coatings or BMP-2 application while offering deep UV penetration across porous structures. Enhanced hydrophilicity and carbon decontamination significantly promote cell adhesion, proliferation, osteogenic differentiation, and in vivo integration.

### Significance/Clinical Relevance:

This study presents a clinically translatable, cost-effective, and equipment-minimal method to improve the osseointegration of 3D-printed porous titanium implants using omnidirectional UV photofunctionalization. It holds promise for improving outcomes in complex bone defect repairs, especially where implant surface aging and poor bone quality pose clinical challenges.