Bioactivity, Biocompatibility, and Antibacterial Properties of Bio-PEEK Interbody Devices

Robert Subtirelu, BA, MSc; Sneha Sai Mannam, BS; Hasan Ahmad, BS; Daksh Chauhan, BS; Ryan Turlip; Yohannes Ghenbot, MD; Connor Wathen, MD; Jang W Yoon, MD; Prabaha Sikder Ph.D

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Introduction

Spinal fusion is a surgical procedure that involves the fusion of vertebral bodies in order to alleviate pain caused by conditions such as spinal degeneration or spinal instability. Conventional spinal fusion procedures using metal or polyetheretherketone (PEEK) cages are limited by a high rate of implant failure, low bioactivity, and bacterial infections. Strategies to make PEEK bioactive have not been successful; there is a need for new technology to prevent device failure, rehospitalization, and resource waste. The integration of novel bioactive ceramics with Fused Filament Fabrication (FFF) has the potential to revolutionize the field, providing a new approach for enhancing osseointegration while reducing the risk of implant failure and bacterial infection. In this study, we evaluate the biocompatibility, bioactivity, and antibacterial attributes of Bio-PEEK, a first-of-its-kind interbody device.

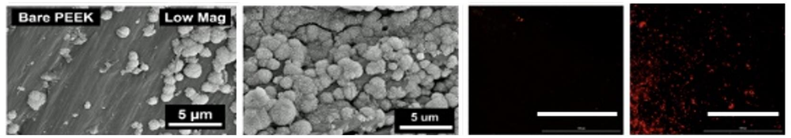
Objectives

The objective of this study is to evaluate the biocompatibility, bioactivity, and antibacterial properties of Bio-PEEK in comparison to conventional PEEK cages.

Results

Bio-PEEK demonstrated improved biocompatibility compared to PEEK, as the number of cells adhered to Bio-PEEK was higher (a thick cell layer was observed on Bio-PEEK). Bio-PEEK showed higher bioactivity compared to bare PEEK, as a larger amount of bone-like apatite was deposited on Bio-PEEK after immersion in SBF. The novel cage exhibited faster cell growth kinetics as confirmed by the MTT assay. LIVE/DEAD analyses indicated the remarkable antibacterial properties of Bio-PEEK, as the number of live bacteria was significantly lower compared to bare PEEK, while the number of dead bacteria was higher. Furthermore, SEM image analysis demonstrated Bio-PEEK's ability to inhibit biofilm formation, as less S. aureus adhered to Bio-PEEK compared to bare PEEK.

A. B.



Bioactivity and Antibacterial Properties of Bio-PEEK. A. SEM images show copious apatite formation on Bio-PEEK as opposed to bare PEEK.
B. LIVE/DEAD assay demonstrate that red dots (dead S. aureus) are notably more on Bio-PEEK.

Methods

The cages were developed using optimized FFF parameters to develop 3D-printed Bio-PEEK IBF cages with high print resolution. The cages were produced using precise temperature parameters to minimize defects and pores. Biocompatibility was assessed using an inductively coupled plasma (ICP) analysis. Mouse pre-osteoblasts (MC3T3-E1, CRL-2593™, ATCC) were seeded directly onto Bio-PEEK filaments, and the number of cells adhered was observed and compared to those adhered to PEEK. The Bio-PEEK cages were immersed in Simulated Body Fluid (SBF) at 37° C for 7 days; the amount of bone-like apatite deposited was compared to that on bare PEEK to determine bioactivity. Cell growth kinetics, and cytotoxicity, were determined using a Thiazolyl blue tetrazolium bromide (MTT) assay. Antimicrobial properties were assessed using LIVE/DEAD analysis. The ability of Bio-PEEK to inhibit biofilm formation was confirmed using scanning electron microscopy (SEM) images comparing the adherence of S. aureus on Bio-PEEK to that on bare PEEK.

Conclusion

The results of the study suggest that Bio-PEEK has improved biocompatibility, bioactivity, and antibacterial properties compared to PEEK. The utilization of this technology could minimize the use of expensive bone-stimulating proteins, lower the risk of infections, and lead to the development of customized, multi-functional implants with reconstructive applications. These benefits can result in fewer revision surgeries, lower treatment costs, and improved patient outcomes.

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