Surface bioactivation of PEEK by neutral atom beam technology

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A B S T R A C T

Polyetheretherketone (PEEK) is an alternative to metallic implants and a material of choice in many applications, including orthopedic, spinal, trauma, and dental. While titanium (Ti) and Ti-alloys are widely used in many intraosseous implants due to its biocompatibility and ability to osseointegrate, negatives include stiffness which contributes to shear stress, radio-opacity, and Ti-sensitivity. Many surgeons prefer to use PEEK due to its biocompatibility, similar elasticity to bone, and radioluency, however, due to its inert properties, it fails to fully integrate with bone. Accelerated Neutral Atom Beam (ANAB) technology has been successfully employed to demonstrate enhanced bioactivity of PEEK both in vitro and in vivo. In this study, we further characterize surfaces of PEEK modified by ANAB as well as elucidate attachment and genetic effects of dental pulp stem cells (DPSC) exposed to these surfaces. ANAB modification resulted in decreased contact angle at 72.9 ± 4.5° as compared to 92.4 ± 8.5° for control (p < 0.01) and a decreased average surface roughness, however with a nano-textured surface profile. ANAB treatment also increased the ability of DPSC attachment and proliferation with considerable genetic differences showing earlier progression towards osteogenic differentiation. This surface modification is achieved without adding a coating or changing the chemical composition of the PEEK material. Taken together, we show that ANAB processing of PEEK surface enhances the bioactivity of implantable medical devices without an additive or a coating.

1. Introduction

Over the past two decades, polyetheretherketone (PEEK) has been increasingly used as an alternative to metal implants in orthopedic and dental surgery because of its mechanical and biological properties as well as its radioluency. One of the main reasons to use PEEK in place of metal alloys is to eliminate concerns regarding potential metal allergies [1,2]. The ability to manipulate the modulus of elasticity of PEEK to more closely match that of bone reduces the possibility of stress shielding and bone resorption. Despite the benefits of PEEK, its inert nature means that it fails to promote an adequate bone integration. Many surgeons prefer to use PEEK due to its biocompatibility, similar elasticity to bone, and radioluency, however, due to its inert properties, it fails to fully integrate with bone. Accelerated Neutral Atom Beam (ANAB) technology has been successfully employed to demonstrate enhanced bioactivity of PEEK both in vitro and in vivo. In this study, we further characterize surfaces of PEEK modified by ANAB as well as elucidate attachment and genetic effects of dental pulp stem cells (DPSC) exposed to these surfaces. ANAB modification resulted in decreased contact angle at 72.9 ± 4.5° as compared to 92.4 ± 8.5° for control (p < 0.01) and a decreased average surface roughness, however with a nano-textured surface profile. ANAB treatment also increased the ability of DPSC attachment and proliferation with considerable genetic differences showing earlier progression towards osteogenic differentiation. This surface modification is achieved without adding a coating or changing the chemical composition of the PEEK material. Taken together, we show that ANAB processing of PEEK surface enhances the bioactivity of implantable medical devices without an additive or a coating.

https://doi.org/10.1016/j.bioactmat.2019.02.001
Received 26 October 2018; Received in revised form 31 January 2019; Accepted 9 February 2019

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