Accelerated Neutral Atom Beam Technique Enhances Bioactivity of PEEK

J. Khoury, M. Maxwell, R. E. Cherian, S. R. Kirkpatrick, and R. C. Svrluga
Exogenics Corp, Billerica, MA 01821

Introduction:
Polyetheretherketone (PEEK) is continuing to gain popularity in orthopedic and spinal uses. PEEK has displaced titanium (Ti) as the predominant material in spinal applications. Ti is both biocompatible and bioactive but has a high modulus of elasticity and is difficult to image with X-rays. PEEK is biocompatible, similar in elasticity to bone, and radiolucent; however, a drawback of PEEK is it has been shown to be inert and does not integrate material in spinal applications. Ti is both biocompatible and bioactive but proliferation. In this study, we sought to understand the effects of ANAB treatment of PEEK surfaces in order to increase bioactivity and biointegration of implantable medical devices.

Materials and Methods
PEEK film disks of 1cm Ø were treated with nanoAccel at 5e16 Ar ions/cm² or left as controls. Atomic force microscopy (AFM) measurements were performed in non-contact mode for 1µm regions (Park Systems XE-70) and Rz and Rq measurements were calculated. Contact angle was measured using the sessile drop method on a manual simplified device as described by Lamour et al. (2010) and droplet angles were measured by ImageJ software (NIH) with the contact angle plugin. For proliferation studies, human osteoblasts (2000/cm²) were seeded onto the surface and allowed to proliferate for 14 days. Disks were then stained with crystal violet, visualized by light microscopy, and eluted to measure absorbance, inferring cell number. Gene expression studies were performed by real time PCR for IBSP, osteopontin (SP7), and ostein (SP7) and corrected with GAPDH. An in vivo study using a rat calvarial critical size defect model was done to show bone growth on the surface of nanoAccel-treated and –untreated PEEK disks 3mm Ø, 1 mm thick. 4 weeks after implantation, histology was performed to determine the amount of bone re-growth on the surface.

Conclusions
nanoAccel results in a nano-scale texturing and improved hydrophilicity on otherwise chemically resistant PEEK. The resulting processing of PEEK by nanoAccel significantly enhances osteoblast cell attachment and proliferation. nanoAccel treatment of PEEK increases the cytoactivity of PEEK to match that of TCPS. Enhanced osseointegration was demonstrated in the in vivo study where bone formation was evident only on the nanoAccel treated PEEK. Taken together, these data strongly suggest that nanoAccel treatment of PEEK enhances bone formation and may significantly decrease osseointegration time for orthopedic implants.

Benefits of nanoAccel Processing
- nanoAccel alters the surface structure to a depth of ~10nm
- nanoAccel enhances surface hydrophilicity
- nanoAccel encourages better cell attachment and proliferation
- nanoAccel leads to enhanced osteogenic gene expression and earlier bone formation

Results Continued

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<tr>
<th>Gene</th>
<th>Increase in Expression vs. Control</th>
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<tr>
<td>IBSP</td>
<td>36.86% +/- 7.19%</td>
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<tr>
<td>SP7</td>
<td>73.34% +/- 3.08%</td>
</tr>
<tr>
<td>SPP1</td>
<td>82.00% +/- 4.16%</td>
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nanoAccel treatment leads to significant upregulation of osteogenic pathway genes at 14 days post-seeding.

Results.

The critical size defect model shows significant bone growth on the treated surface. Coverage is approximately 50% of the PEEK surface after 4 weeks. Control PEEK showed no bone growth on the PEEK and showed signs of bone resorption.

Control nanoAccel-Treated

Osteoblast proliferation on PEEK film was significantly higher on nanoAccel treated PEEK disks compared to control.

Questions or Further Information
Contact:
Joseph Khoury, PhD
Director, Cell and Molecular Biology
Exogenics Corp
20 Fortune Drive
Billerica, MA 01821
Tel: (781) 439-0120
Email: jkhoury@exogenics.us