A Cost-Effective Approach to Enhance PEEK Roughness and Osteoblast Adhesion Using Sodium Chloride as a Pore-Forming Agent

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INTRODUCTION: Polyether ether ketone (PEEK) is a thermoplastic polymer that mimics bone biomechanically and is, therefore, commonly used in orthopedic implants. However, applications of PEEK are limited by its bio-inert nature, which limits osteoblast adhesion and differentiation into bone which compromises osseointegration. Surface functionalization, plasma treatments, laser etching, and sand blasting have been tested to improve cell adhesion, but these methods require costly, specialized equipment. In this study, we propose to use a cost-effective method to enhance roughness and cell adhesion on PEEK by adding sodium chloride (NaCl) as a pore-forming agent. By incorporating NaCl crystals into PEEK powder, pores are created in the prepared discs when the salt is dissolved in water, mimicking osteoclast resorption pits. Pore size and percentage can be controlled by adjusting the size and the amount of NaCl added to the PEEK powders.

METHODS: Pellets were made of PEEK granules mixed with NaCl as porogen. This mixture included 1%, 2.5%, 5%, 10%, 25%, 50% NaCl by mass, with the remainder consisting of PEEK. The NaCl crystal size was 30 μm, which was ground and collected using standardized sieves. The pellets were pressed using a manual press and sintered at 380°C for 8 minutes before the NaCl was dissolved in deionized water. Morphology was assessed using scanning electron microscopy. Wettability was measured via water contact angle. Surface roughness was evaluated using a 3D optical profilometer. Mechanical properties were measured using a universal testing machine. Cell adhesion, proliferation, and differentiation were assessed using human osteoblasts. Statistical analyses were performed using the t-test, with statistical significance set at $P < 0.05$.

RESULTS: The wettability of porous PEEK varied slightly with the mass percentage of added NaCl in the original mixture. Samples with 50% NaCl exhibited the highest contact angle, likely due to increased porosity percentage. The addition of NaCl particles resulted in increased roughness, higher porosity percentage, and improved osteoblast adhesion on the surface of PEEK discs. NaCl concentrations of 5% and higher showed significantly enhanced cellular adhesion at 16 hours compared to other porous and non-porous PEEK samples.

DISCUSSION: Enhancing porosity and roughness of PEEK-based implants can improve osteoblast adhesion to the implant. Future work on this project would include expanding the range of NaCl granule sizes; investigating how the size of the NaCl granule, and therefore the resultant pore, affects osteoblast adhesion and proliferation.

SIGNIFICANCE/CLINICAL RELEVANCE: Optimizing PEEK surface porosity is expected to promote bone formation at the peri-implant interface, thereby improving the performance of PEEK-based implants in orthopedic applications.

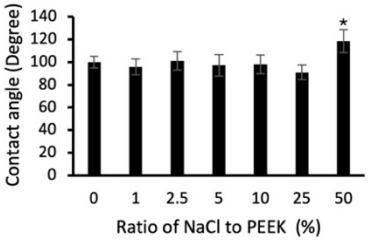

Figure 1. Contact Angle of PEEK discs: effect of NaCl content on wettability.

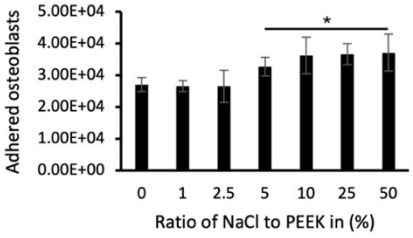

Figure 2. Osteoblasts adhesion on PEEK discs made by increased concentrations of NaCl particles at 16 hours.