Implants Treated with Discrete Crystalline Depositions of Nanometer-scale Calcium Phosphate Crystals Enhance Early Implant-Bone Fixation in a Rat Femur Push-In Model

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Statement of Purpose: The topography and biochemical properties of titanium implant surfaces influence the rate and extent of adherent de novo bone formation. This study uses a rat femur push-in model to demonstrate early bone fixation of implants treated with discrete crystalline depositions (DCD) of nanometer-scale calcium phosphate crystals added to a dual acid-etched (DAE) surface.

Materials and Methods: Cylindrical miniature Ti6V4Al implants, 1mm (D) x 2mm (L), were modified with the dual acid-etched (DAE) surface treatment (Osseotite®, 3i Implant Innovations Inc, Palm Beach Gardens, FL). Test implant surfaces were additionally treated with DCD of nanometer-scale calcium phosphate crystals (NanoTite™). The implant surfaces were examined by SMM, EDS, and SEM. Each of 24 male Sprague-Dawley rats received one Test implant in the distal end of one femur and one Control implant in the other femur. Animals were divided into groups and sacrificed after 4, 7 and 14 days of healing. The femur-implant specimens were harvested and embedded in resin blocks. An Instron equipped with a custom-made stainless steel pushing rod was applied to the implant to determine the peak push-in force at which the implant detached from bone [1,2].

Results/Discussion: SMM revealed that the underlying microtopography of the DAE surface was indistinguishable on both types on implants. EDS measurements at different areas indicated that the DCD implant surface chemistry was uniformly modified with Ca and P elements. High-resolution SEM revealed the size of the depositions of calcium phosphate crystals to the Ti6V4Al surface to be 20-40 nm. Mean peak push-in forces at 4 (n=7), 7 (n=7) and 14 (n=10) days for Test implants were 5.86 ± 1.82N, 29.04 ± 10.95N, and 37.48 ± 17.58N, respectively, and for Control implants were 5.54 ± 1.27N, 27.98 ± 7.53N, and 25.35 ± 9.87N, respectively (P<0.05 at day 14) (Figure 1). Both implant groups exhibited a substantial increase of mechanical resistance from day 4 to day 7. From day 7 to day 14, the peak push-in value for the Control group stabilized, whereas the peak push-in values for the Test group increased. The time-course pattern of early implant fixation process appeared to be different between Test and Control implants.

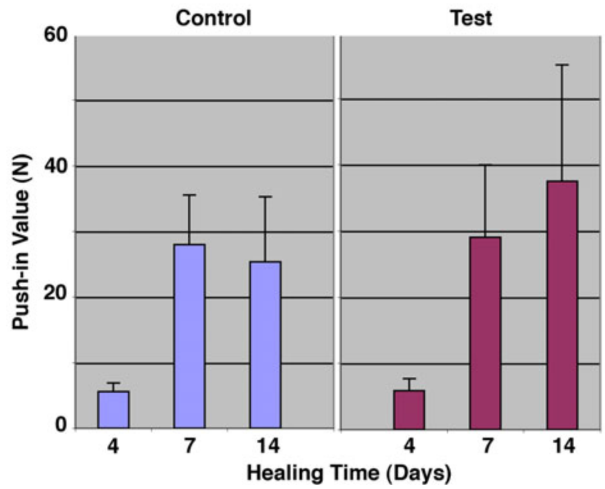

Figure 1: Implant push-in test in the rat femur model. All implants have the DAE surface. Test implant surfaces were additionally treated with DCD.

Conclusion: This biomechanical model demonstrates a significant increase in bone fixation for Test implants at 14 days, and suggests that while the DCD surface treatment did not alter the predisposing surface microtopography of the DAE implant substrate, the nanometer-scale calcium phosphate crystals appear to affect early implant fixation processes by a potentially unique mechanism.

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