Dissolution of Discrete Calcium Phosphate Crystals from Candidate Ti-based Implant Surfaces

[1]Padina Pezeshki, Stanley Lugowski, and [1,2]John E. Davies*
[1,2]Faculty of Dentistry, University of Toronto, Toronto, ON, [2]Institute of Biomaterials and Biomedical Engineering, University of Toronto, Toronto, ON,
e-mail: padina.pezeshki@utoronto.ca

Statement of Purpose: Plasma-spraying of bone implants with CaP accelerates peri-implant healing and renders implant surfaces bone bonding. Clinical success has been achieved, but problems have also been identified due to disintegration and delamination of thick (~ 50µm) coatings (1). Also, the associated high temperature, results in a heterogeneous coating comprising several CaP phases (2). Thus, the solubility of coatings has been a subject of considerable study, and different fabrication methods have aimed to modify the properties that influence the CaP dissolution rate. A recent means of modifying surfaces with CaP comprises deposition of discrete crystals (DCD) of CaP (20-100 nm) onto the metal surface. Our current study was designed to quantify the amount and dissolution kinetics of these discrete CaP crystals from dental implant surfaces and compare their behavior with commercially-available plasma sprayed CaP coated implants of a similar size. We chose an investigational pH range of 4-7 for our experiments.

Methods: DCD-treated implants (6mmØx15mmL) and plasma sprayed CaP implants (6mmØx13mmL) were supplied by Implant Innovations Inc (***3i***) (Palm Beach Gardens, FL). The experiments measured (i) total amount of Ca on the surface and (ii) amount of Ca released in pH-specific solutions. All experimental equipment was initially cleaned to remove containing Ca contaminants. For determination of total Ca, each DCD-treated implant was immersed in 10 ml of 1 M Ultrex Grade HCl (pH 0) for 15 min and each plasma sprayed sample for 16 hrs (n=8). For the second part of the experiment, samples were placed in 10 ml of saline solution with fixed pH of 4, 5, 6, or 7 for 15 min (n=3). The samples were then removed and the total Ca in the remaining solution was measured using atomic absorption spectrophotometry. Furthermore, the morphology of the surfaces was qualitatively analyzed using field emission scanning electron microscopy.

Results/Discussion: The results showed that DCD-treated implants had 3 orders of magnitude less CaP than plasma sprayed implants. As DCD-treatment is not a coating, delamination is not a potential problem, and as the crystals are of the nanometer scale range, should they become detached from the implant surface they can be easily phagocytosed by cells and degraded. Dissolution per unit time showed an inverse relationship with pH. This is relevant to the initial steps of biological healing, where activated macrophages, which randomly contact the implant surface, reduce the local pH to 4. However, at normal body pH of 7.4, the dissolution of CaP from DCD implants is almost zero, while dissolution continues to occur from plasma sprayed implants. Finally, the pH-dependent dissolution of the two implant types demonstrated that the DCD had an homogeneous CaP phase while plasma sprayed samples were multi-phasic.

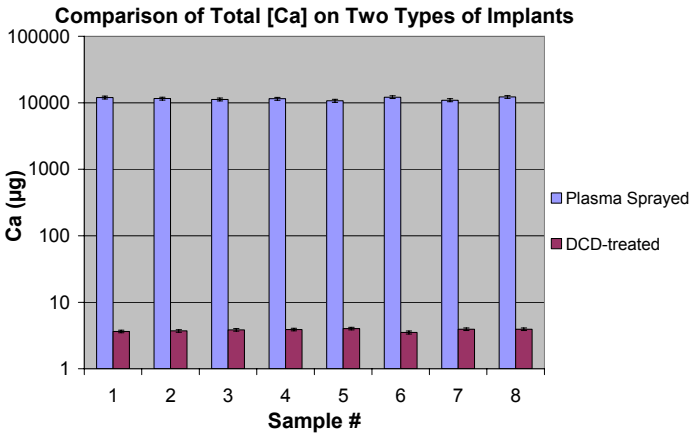

Figure 1: Comparison of total [Ca] on plasma sprayed and DCD-treated implants

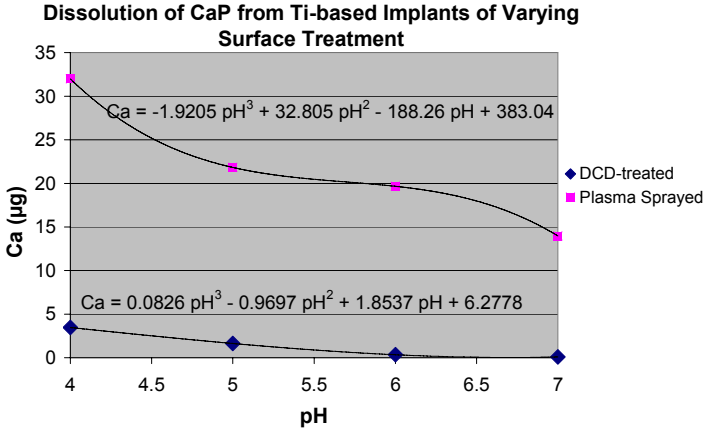

Figure 2: Dissolution trends of plasma sprayed and DCD-treated implants

Conclusions: DCD-treatment provides the surface with the advantages of CaP while utilizing over 3000 times lower coverage than traditional plasma spraying. The treatment also retains a homogenous and stable phase of CaP compared to the more soluble and hence undesirable multi-phase CaP coverage achieved through plasma spraying.

References: **1.** Sun *et al.*, J Biomed Mater Res. 2001;58(5):570-92. **2.** Yang *et al.*, J Biomaterials 2005; 26 327-337. **3.** Zeng *et al.*, J Biomaterials 1999; 20 (5): 443-351

Acknowledgements: We are grateful for financial support from *3i* and the Ontario Research and Development Challenge Fund (ORDCF).