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Nano-Engineered titanium modulates macrophage polarization towards enhancing osteogenesis

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Statement of the Problem: Macrophages are vital modulators of inflammation, and their relationship with bone cells enables dynamic crosstalk between inflammatory M1 macrophage and regenerative M2 macrophage. It is important to modulate immune response as the first stage for tissue regeneration, wound healing at the bone, dental implant micro-environment, and hence studies have aimed at achieving tailored immune responses on Ti implants by means of surface modification. More recently, nano-engineered titanium with titania nanostructures: nanotubes or nanopores (TNS) have been suggested as favourable bone implant surfaces.

Methodology & Theoretical Orientation: Nanopores (50 nm and 70 nm diameter, TNS-50 and TNS-70) on Ti surfaces were fabricated by anodization process and characterized by SEM imaging. Then, we investigated the effect of TNS in Mo macrophage differentiation and also examined macrophage phenotype switching from M1 and M2 macrophage using immunofluorescence staining, cytokine levels and gene expression. In addition, we elucidated osteogenic effect of macrophages indirectly co-cultured with pre-osteoblasts (MC3T3-E1 cell) on these surfaces using ALP activity and Alizarin red staining.

Findings: Our results showed that TNS increased M2 macrophage phenotype expression from Mo and M1-induced macrophage. In particular, TNS-70 significantly upregulated M2 macrophage marker expression. Also, we found that co-cultured with macrophage subtypes on TNTs increased the osteogenic ability of pre-osteoblasts.

Conclusion & Significance: TNS modified Ti enhanced the M2 macrophage phenotype and promoted osteogenesis, which has implications for bone healing in the implant micro-environment. This study will help to optimize and understand a potential underlying cellular mechanism responsible for improved bone healing for nano-engineered Ti implants. These results will thus facilitate the development of immune-responsive implantable Ti prostheses towards bone regeneration.

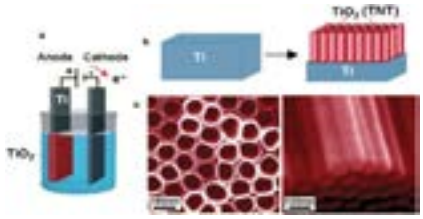

Fig 1. Fabrication of titania nanotubes (TNTs) on titanium. (a) Schematic representation of the electrochemical anodization setup, (b) illustration of the TNTs on Ti surface, and (c) scanning electron microscopy images showing open pores and closed base (Gulati et al. Ther Deliv 3(7) 2012)

Biography

Ho-Jin Moon is a Postdoctoral Research Fellow at School of Dentistry and Oral Health, Griffith University in Australia. He is an emerging Bone Immunologist with a keen interest in interactions and signalling mechanisms between osteoblast and macrophage (osteoclast) on biomaterial surfaces. He firstly started from molecular biology interest and have developed to cell response on multi-functional scaffolds for bone healing. He was awarded his Master's and PhD degree in South Korea and then joined Tissue Engineering and Regenerative Medicine group in MenziesHIQ of Griffith University. His research interests include regenerative medicine and tissue engineering based on molecular biology to characterize the molecular basis of bone healing. He was awarded Griffith University Postdoctoral Fellowship (2016-2017) in Australia and Fostering Next-generation Researchers Program for Postdoc from the National Research Foundation of Korea (2017-2018).

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