Developing CNTs-Ti-based Biosensors for Monitoring Orthopedic Tissue Growth

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Statement of Purpose: The objective of this present study was to create a biosensor which can monitor in situ orthopedic tissue growth juxtaposed to a newly implanted orthopedic material. This biosensor has unique properties including the ability to sense, detect, and control bone regrowth. Such a biosensor is useful not only in regenerating tissue necessary for orthopedic implant success, but also to aid in informing an orthopedic surgeon whether sufficient new bone growth occurred. If the sensor determines that insufficient new bone growth occurred, the sensor can also act in an intelligent manner to release bone growth factors to increase bone formation.

Methods: The primary biomaterial in this biosensor is anodized titanium, developed by chemical etching and passivation treatments. Carbon nanotubes (CNTs), because of their electrical and mechanical properties, are essential to consider when designing such biosensors since they will be used to apply and measure conductivity changes as new bone grows next to the implant. For this, parallel multiwalled CNTs were grown from the pores of the anodized titanium by the chemical vapor deposition process. Lastly, these sensors are composed of a conductive, biodegradable, polymer layer that degrades when bone grows and, consequently, undergoes a change in conductivity that can be measured by the CNTs grown out of the anodized titanium. This conductive, biodegradable polymer consists of polypyrrole (which is conductive) and poly-lactic-co-glycolic acid (which is biodegradable).

Results: The preliminary results in vitro, as shown in Figure 1 and 2, suggest that osteoblast adhesion and proliferation on such a biosensor are not significantly compromised when compared to currently-used titanium, yet retain the ability to potentially measure new bone growth juxtaposed to an implant. In addition, although not tested here, it is anticipated that bone growth will be enhanced on these biosensors electrically via CNTs growth. Figure 3 shows an osteoblast in connection with CNTs, thus potentially electricity can pass through osteoblasts via these CNTs when subjected to voltage.

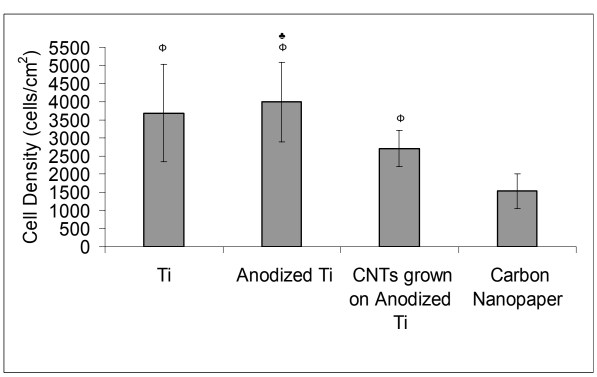

Figure 1. Osteoblast Adhesion on Ti, Anodized Ti, CNTs Grown on Anodized Ti, and Carbon Nanopaper. Values are mean ±S.E.M; n=3; ♣ $p<0.1$ compared to CNTs grown on Anodized Ti; Φ $p<0.1$ compared to Carbon Nanopaper.

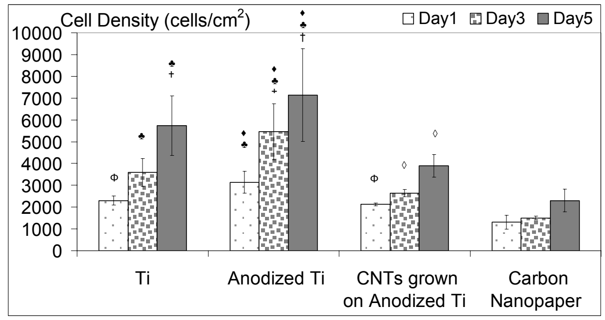

Figure 2. Osteoblast Proliferation on Ti, Anodized Ti, CNTs Grown on Anodized Ti, and Carbon Nanopaper. Values are mean ±s.e.m; n=3; ♦ $p<0.1$ compared to Ti; ♣ $p<0.1$ compared to CNTs grown on Anodized Ti; Φ $p<0.1$, † $p<0.05$, ◊ $p<0.02$ compared to Carbon Nanopaper.

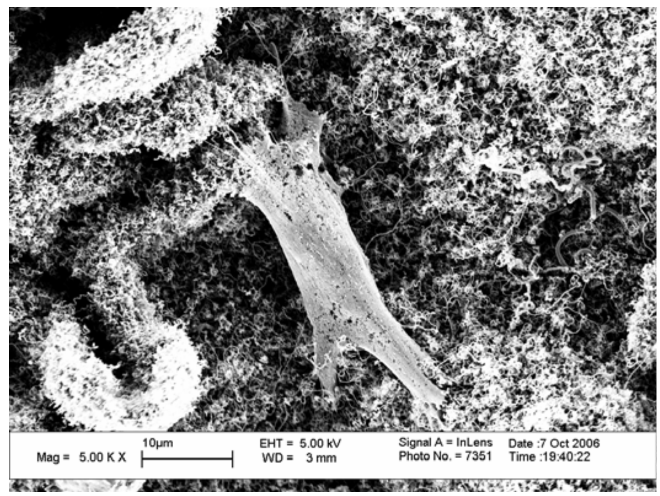

Figure 3. SEM micrograph of an osteoblast adherent on CNTs grown on Anodized Ti.

Conclusions: Preliminary results in vitro showed that unanodized Ti had similar osteoblast adhesion compared to anodized Ti in which CNTs were grown. For cell proliferation for days 1, 3, and 5, it was found that CNTs grown from anodized Ti samples had less cells than pure Ti, and anodized Ti. Moreover, this experiment supports an earlier study [1] that showed greater osteoblast adhesion on anodized Ti surfaces possessing nano-tube-like structures compared to the unanodized Ti. It does provide the first evidence of less osteoblast functions on CNTs grown from Ti anodized pores compared to anodized Ti alone but such results were comparable to currently used Ti.

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References:

1. C. Yao, et. al (2005), Journal of Biomedical Nanotechnology, 68-73.