

## Magnetoelastic Materials as Novel Bioactive Coatings for Control of Cell Adhesion

E. Vlaisavljevich, K.C. Scott, K.G. Ong, R.M. Rajachar

Michigan Technological University, Houghton, MI

**Statement of Purpose:** A novel materials-based approach has been developed to mitigate fibrous growth associated with implantable biomaterials. Specifically, a bioactive vibrational coating was developed to modulate local cell adhesion. The coating is based on a magnetoelastic (ME) material that can be remotely set to vibrate at a predetermined amplitude and frequency. In an AC magnetic field, the material changes dimensions converting magnetic energy into mechanical vibrations. ME materials have shown potential as bio-sensors, and the aim of this work was to determine if the unique character of these materials could be used as a therapeutic tool to control cell adhesion. We hypothesize that small local vibrations can selectively modulate cell adhesion to minimize fibrosis and promote proper integration at the tissue-implant interface.

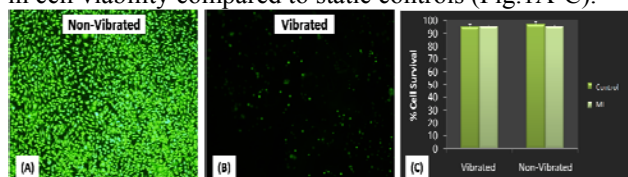
### Methods:

**Cell adhesion to bio-activated ME material.** L929 fibroblasts were cultured ( $2 \times 10^4$  cells/cm<sup>2</sup>) on ME materials coated with polyurethane and chitosan for 2, 4, and 6 days followed by vibration (2hrs, 170-176 Hz). Cell adhesion post-vibration was assessed with fluorescence imaging. Percent cell survival was determined for adherent and detached cells relative to static controls.

**Substrate affects cell adhesion with sub-micron vibration.** The effect of the polymer substrate on cell adhesion was compared using chitosan and poly-L-lactic acid (PLLA). Cells were cultured for two days on ME materials spin-coated with chitosan or PLLA followed by vibration and imaging.

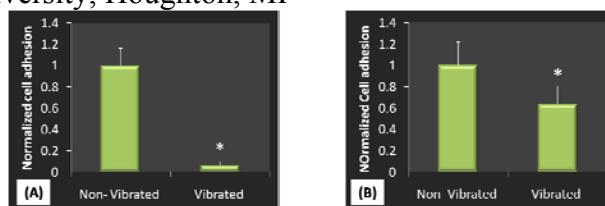
**Material vibration profile affects cell adhesion.** Material vibration profiles (strain amplitude/interval delay) were altered to determine affect on cell adhesion. Strain amplitudes (0.117 $\mu$ m and 0.1542 $\mu$ m) (Fig.3A) or interval delays (1s and 10s) (Fig.3C) were applied after 2 days culture followed by imaging.

**Results:** The results indicate that controlled sub-micron vibrations can induce cell detachment without a decrease in cell viability compared to static controls (Fig.1A-C).



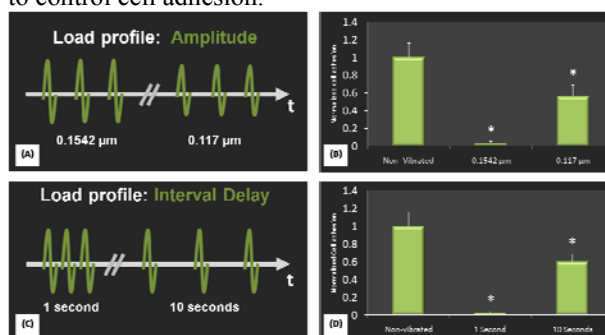
**Figure1.** ME vibrations prevent adhesion without decreasing cell viability. (A) Non-vibrated; (B) Vibrated (2hrs); (C) Viability of re-suspended cells.

Additionally, substrate composition appears to significantly affect the cell adhesion response to sub-micron vibrations, suggesting that substrate patterning could be used to tailor coatings that are spatially mechanically cell selective (Fig.3).



**Figure2.** Coating material with PLLA significantly increases cell attachment post-vibration. Measure of cell attachment to ME material coated. (A) chitosan or (B) PLLA. \*Significant difference.

Lastly, increasing vibration amplitude (Fig.4B) or decreasing recovery time (Fig.4D) significantly influenced cell adhesion in a substrate dependent manner, suggesting that tunable vibration parameters can be used to control cell adhesion.



**Figure3.** Vibration profile changes adhesion behavior. Normalized cell attachment after vibration under changed amplitude (B) and delay interval (D). \*Significant increase in attachment at lower amplitude or longer recovery interval.

**Conclusions:** This work demonstrates the potential of a novel ME-based biomaterial for site-specific control of cell adhesion. These materials are remotely tunable (adjustable *in situ*) and capable of real-time self-monitoring (secondary magnetic field created during vibration provides feedback on adhesion to the substrate), allowing therapy to be delivered on an as needed basis via a wireless activation coil for the life of the implant.

The results of this work provide the basis for a novel approach to fundamental issues regarding the host response to implantable biomaterials. Current work is underway to fully characterize the activated ME surface (i.e. contact angle measures, AFM surface analysis) and to make preliminary *in situ* measures regarding the host response. Overall, this work demonstrates the development of a novel biomaterial that generates sub-micron vibrations that can control cell adhesion without inducing cell death.

**Acknowledgements:** Authors would like to thank Dr. Kai-Nan An (Mayo Clinic) for his comments and support regarding this work.