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A Bioinspired Anti-Fouling Coating for Implantable Medical Devices

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Abstract : As the fields of medicine and bionics grow rapidly in technological advancement, the future and success of it depends on the ability to effectively interface between the artificial and the biological worlds. The biggest obstacle when it comes to implantable, electronic medical devices, is maintaining a ‘clean’, low noise electrical connection that allows for efficient sharing of electrical information between the artificial and biological systems. Implant fouling occurs with the adhesion and accumulation of proteins and various cell types as a result of the immune response to protect itself from the foreign object, essentially forming an electrical insulation barrier that often leads to implant failure over time. Lubricin (LUB) functions as a major boundary lubricant in articular joints, a unique glycoprotein with impressive anti-adhesive properties that self-assembles to virtually any substrate to form a highly ordered, ‘telechelic’ polymer brush. LUB does not passivate electroactive surfaces which makes it ideal, along with its innate biocompatibility, as a coating for implantable bionic electrodes. It is the aim of the study to investigate LUB’s anti-fouling properties and its potential as a safe, bioinspired material for coating applications to enhance the performance and longevity of implantable medical devices as well as reducing the frequency of implant replacement surgeries. Native, bovine-derived LUB (N-LUB) and recombinant LUB (R-LUB) were applied to gold-coated mylar surfaces. Fibroblast, chondrocyte and neural cell types were cultured and grown on the coatings under both passive and electrically stimulated conditions to test the stability and anti-adhesive property of the LUB coating in the presence of an electric field. Lactate dehydrogenase (LDH) assays were conducted as a directly proportional cell population count on each surface along with immunofluorescent microscopy to visualize cells. One-way analysis of variance (ANOVA) with post-hoc Tukey’s test was used to test for statistical significance. Under both passive and electrically stimulated conditions, LUB significantly reduced cell attachment compared to bare gold. Comparing the two coating types, R-LUB reduced cell attachment significantly compared to its native counterpart. Immunofluorescent micrographs visually confirmed LUB’s antiadhesive property, R-LUB consistently demonstrating significantly less attached cells for both fibroblasts and chondrocytes. Preliminary results investigating neural cells have so far demonstrated that R-LUB has little effect on reducing neural cell attachment; the study is ongoing. Recombinant LUB coatings demonstrated impressive anti-adhesive properties, reducing cell attachment in fibroblasts and chondrocytes. These findings and the availability of recombinant LUB brings into question the results of previous experiments conducted using native-derived LUB, its potential not adequately represented nor realized due to unknown factors and impurities that warrant further study. R-LUB is stable and maintains its anti-fouling property under electrical stimulation, making it suitable for electroactive surfaces.

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