Engineering Surface Chemistries to Improve Tissue-Material Integration in Medical Implants

Vale, Vinjai

Tissue-material integration is a key challenge of engineering medical implants and implantable biosensors. Implants often undergo an intense foreign body reaction orchestrated by human macrophages (hMfs), leading to severe inflammation and expensive revision surgeries, potentially interfering with the functioning of an implanted biosensor. This in vitro study investigated the potential of low-cost porous silicone-gel scaffolds with various mussel-inspired polydopamine (PDA)-based surface coatings as medical implant surfaces. Scaffolds of varying pore sizes (50-500μm) were modified with PDA, cell adhesive RGD peptide, and growth factor TGF-ß. The proliferation and extracellular matrix (ECM) secretion of human dermal fibroblasts (hDFs) on these scaffolds were studied in the presence and absence of hMfs, yielding a relatively holistic in vitro model of the tissue regeneration process around the implant. Three separate investigations were conducted. The first measured cytokine release profiles of hMfs cultured on scaffolds, showing that PDA-based coatings halved release of TNF-a (a major pro-inflammatory cytokine). The second experiment refined and validated the novel “flipped-floater” system for co-culturing hDFs and hMfs. The third experiment studied hDFs both alone and co-cultured with hMfs using the flipped-floater system. hDFs on their own exhibited around twice the proliferation on PDA as on uncoated scaffolds, and PDA provided a seven-fold boost with hMfs present. 100-300μm pores yielded the best performance. SEM pictures show hDFs growing up to 500μm deep and secreting healthy ECM on PDA-coated scaffolds. These results indicate that PDA coatings with properly-structured scaffolds have significant potential to improve tissue-material integration in medical implants.

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