Development of Gelatin-Based Biodegradable Thin Films for Controlled Sustained Release of MonteLipid Mediator Analogues

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Vascular injury initiates a cascade of inflammatory responses that disrupt tissue repair and elevate the risk of restenosis and thrombosis. Resolvin D1 (RvD1), an endogenous lipid mediator derived from omega-3 fatty acids, facilitates inflammation resolution and vascular regeneration, yet its clinical utility is hindered by rapid systemic clearance and inefficient localized delivery. To overcome these limitations, a 10 μm biodegradable gelatin-based thin film was developed to enable sustained, site-specific RvD1 release. Fabrication involved spin coating for uniform thickness and laser cutting for dimensional precision, with crosslinking density optimized to control bioresorption and achieve a 56-day release profile. In vitro evaluation using vascular smooth muscle cells (VSMCs) revealed that film-mediated RvD1 delivery reduced proliferation by 39%, migration by 22%, and inflammatory cytokine expression by 36%. Characterization methodologies included cell proliferation and wound healing assays, blood flow chambers to mimic physiological shear stress, and diffusional chambers to quantify release kinetics. Scanning electron microscopy confirmed morphological uniformity, and degradation assays validated the film's controlled resorption. To predict in vivo performance, COMSOL Multiphysics was used to simulate drug diffusion, degradation, and tissue response in rabbit arterial models, demonstrating effective localized drug retention and therapeutic delivery. This engineered platform offers a novel solution for modulating vascular inflammation and enhancing tissue regeneration. Its biodegradability, extended release profile, and validated performance suggest strong translational potential for clinical applications in restenosis prevention and vascular repair.

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