Zafirlukast-Loaded PLGA Electrospun Fibers on Silicone Breast Implants: A Biocompatible Scaffold for Reducing Capsular Contracture

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Introduction: Capsular contracture remains the most common complication following reconstructive breast surgery with silicone implants, occurring in 10-30% of patients. This pathological fibrotic response, characterized by excessive collagen deposition and fibroblast proliferation, leads to implant hardening, pain, and deformity. While zafirlukast, a cysteinyl leukotriene receptor antagonist, has shown promise in treating established contracture when administered orally, its systemic delivery is limited by variable bioavailability and potential hepatotoxicity. Localized drug delivery via implant coatings represents an innovative strategy to prevent fibrosis while minimizing systemic exposure. This study investigates electrospun poly(lactic-co-glycolic acid) (PLGA) fibers loaded with zafirlukast as a potential anti-fibrotic coating for silicone breast implants.

Materials and Methods: Zafirlukast-PLGA fibers were fabricated using electrospinning of 18% PLGA solution in hexafluoro-2-propanol/acetone (6:1 ratio) containing 0.25% w/w zafirlukast. Fiber morphology was characterized by scanning electron microscopy (SEM) with diameter analysis using ImageJ. Surface wettability was assessed through contact angle measurements. Biological evaluation employed 3T3 fibroblast and RAW 264.7 macrophage cell lines cultured on fiber mats for 3 and 7 days. Cell viability was quantified using WST-8 assay, while Live/Dead staining provided qualitative assessment of cell distribution and morphology. Experimental groups included: (1) PLGA-only fibers, (2) zafirlukast-PLGA fibers, and (3) tissue culture plastic controls.

Results: SEM analysis revealed uniform, bead-free fiber morphology with random orientation. Incorporation of zafirlukast significantly increased average fiber diameter from 0.593 ± 0.19 μm (PLGA-only) to 0.927 ± 0.31 μm ($p<0.05$). Surface hydrophobicity progressively increased from 87.13° ± 5.48 for PLGA to 93.58° ± 2.96 for drug-loaded fibers, reaching 111.88° ± 4.11 when coated onto implants. Fibroblast viability on PLGA scaffolds decreased to 85.9% compared to control (99.7%), while macrophage viability remained unaffected across all groups. The addition of zafirlukast at 0.25% concentration did not produce significant changes in cellular response, suggesting the need for higher drug loading to achieve therapeutic effects.

Discussion: The developed zafirlukast-PLGA fibers demonstrate excellent morphological characteristics suitable for implant coating applications. The observed reduction in fibroblast viability on PLGA scaffolds, even without drug loading, suggests that the physical properties of electrospun fibers may inherently modulate fibroblast behavior. The increased hydrophobicity of drug-loaded fibers could potentially prolong drug release kinetics, though this requires further investigation. Future studies should focus on: (1) optimizing zafirlukast loading concentration, (2) characterizing in vitro drug release profiles, and (3) evaluating anti-fibrotic efficacy in animal models of capsular contracture. The development of this localized drug delivery system could revolutionize the prevention of capsular contracture, potentially reducing revision surgeries and improving patient outcomes in breast reconstruction.

Conclusion: This study successfully developed and characterized zafirlukast-loaded PLGA electrospun fibers as a potential anti-fibrotic coating for silicone breast implants. While demonstrating good biocompatibility, the current formulation requires optimization of drug loading to enhance therapeutic effects. The electrospinning approach offers a promising platform for localized delivery of anti-fibrotic agents, with potential for clinical translation as an intraoperative implant coating strategy.