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Development of Antifibrotic Nanofiber Implants For Glaucoma Treatment

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Extended Abstract

Glaucoma is a group of eye diseases that damage the optic nerve, often due to increased intraocular pressure (IOP). If left untreated, it can lead to gradual vision loss and even blindness. The most common types include open-angle glaucoma and angle-closure glaucoma. Treatment primarily focuses on lowering IOP to prevent further damage. Common methods include medications, such as eye drops that reduce fluid production or improve drainage, laser therapies like trabeculoplasty to enhance fluid outflow, and surgical procedures such as trabeculectomy or drainage implants for severe cases. Early detection through regular eye exams is crucial for effective management [1–3].

Nanofiber materials are being explored as an innovative solution for the development of glaucoma drainage implants, which help reduce IOP by improving the outflow of aqueous humor. Traditional implants are prone to scarring and blockage, which can limit their long-term effectiveness. Nanofiber structures enable the creation of highly porous and biocompatible surfaces that minimize inflammatory reactions and support stable implant function. With unique properties, such as a high surface-to-volume ratio and controlled drug release capabilities, nanofiber-based implants can enhance treatment efficacy and extend the lifespan of these devices. Research is focused on optimizing materials, such as biodegradable polymers, which may allow for gradual resorption of the implant without the need for follow-up surgical intervention [4–6].

A key advancement in this field is the development of antifibrotic nanofiber implants, which not only reduce IOP but also minimize scarring and fibrosis, common complications after glaucoma surgery. The antifibrotic properties are achieved by incorporating materials that prevent or reduce scar tissue formation. Nanofiber structures, with their high surface area and tunable properties, are ideal for gradually releasing antifibrotic drugs, promoting better healing and preventing excessive fibrosis. Biocompatible materials are used for creating the nanofibers due to their stability, durability, and ability to support the gradual release of therapeutic agents. These implants are designed to ensure proper fluid drainage while integrating with surrounding ocular tissues without causing adverse reactions. By incorporating antifibrotic drugs like corticosteroids, the implant aims to reduce the risk of scarring around the drainage site, ensuring long-term functionality. This innovative approach represents a promising solution to improve the success of glaucoma treatments, especially for patients requiring surgical intervention to control IOP. [7–10]

In our study, polyvinylidene fluoride (PVDF, Sigma-Aldrich; Mw: 180,000 g/mol) was selected for the creation of the nanofiber glaucoma implant. To prepare the solution, PVDF was dissolved in dimethylacetamide (DMAc) at 80°C for 24 hours. After the PVDF was fully dissolved, heating was turned off, and once the solution cooled, acetone was added. The solution was then mixed for an additional 30 minutes. The final concentration of PVDF was 26 wt%. Antifibrotic agents were subsequently added to the prepared solution and mixed for another 30 minutes. The solution was electrospun using needle-free electrospinning on a Nanospider NS 1WS500U device. The morphology of the produced layers, fiber diameter, layer thickness, and contact angle were examined. Subsequently, their cytotoxicity was assessed. The results revealed that the nanofiber implant is non-toxic and exhibits antifibrotic effects.

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