Nanomedicine: Future of Corneal diseases

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Abstract: Nanomedicine tools have been explored to successfully treat various corneal diseases for the restoration of normal vision. The barrier properties of the ocular surface can successfully be overcome through nanodelivery, thereby, enhancing the permeability and pharmacological properties of the drugs. Also, transporting genes into desired corneal cells to interfere with the pathologic process helps cater the disease at a molecular level. With the nanomedicine tools being explored, a targeted approach to treat will definitely improve the corneal disease outcome.

Keywords: corneal diseases; infection; nanoparticles; nanomedicine; nanomaterials; nanodelivery

1. INTRODUCTION:

Nanotechnology has been used in almost every field of medical science including: imaging, diagnosis, biosensing, drug delivery. Nanomedicine is the application of nanotechnology in medicine. It is used to study the functioning of the living cells at the molecular level and nanomaterials to develop newer drug delivery modalities for the treatment of human diseases.

2. NANOMEDICINE TECHNIQUES FOR CORNEAL DISEASES:

2.1 Nanoparticles: Nanoparticles ranging from 1 to 100 nm are widely useful for the nanomedicine. Nanoparticles are broadly classified into: **Metallic nanoparticles** include gold (Au-NPs), sliver (Ag-NPs) and platinum (Pt-NPs) [1]. The **polymeric nanoparticles** are usually prepared from polyethyleneimine (PEI) and have been reported to deliver transgene into human corneal epithelial cells and endothelial cells *in vitro* [2,3]. **Hybrid nanoparticles** are the most widely used metallic nanoparticles conjugated with polymeric compounds and can bind large therapeutic genes, for which they are being explored in corneal nanomedicine development [4]. **Non-metallic nanoparticles** such as calcium phosphate nanoparticles (CaP-NPs) functionalized with pcDNA3-EGFP (CaP/DNA/CaP/PEI0.5) have been shown to be an effective tool for transfection in cells.

2.2 Nanofiber scaffolds: They are self-assembling peptides that provide framework and optimal conditions for the **cells and tissue regeneration**. One such example is the cell-sheet engineering approach **to culture corneal endothelial cells under optimal conditions [5].**

2.3 Nanodevices: include the **nanospheres** which contain ciprofloxacin coated on to contact lenses and helps prevent Staphylococcus aureus and Pseudomonas aeruginosa infection [6].

2.4 Nanoadhesives : These are **biomimetic materials** used in tissue engineering to **heal, seal and repair** ocular tissues[7].

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2.5 Nanosponges: provide an **excellent solubility and corneal penetration for drugs** such as dexamethasone [8].

2.6 Single-/multiple-walled Carbon nanotubes (CNTs): The high surface areas and reactivity of the surfaces of CNTs provide **both non-covalent and covalent functionalization of the drugs and fluorescence probes**, thus expanding its potential as a drug carrier as well as for diagnostic purposes [9].

2.6 Nanodelivery: Nanodelivery methods can be broadly classified based on drug packaging as: polymeric nanoparticle, liposomes, dendrimers, nanoemulsions. **Polymeric nanoparticles** (PNs) are colloidal carriers with diameters ranging from 10 to 1000 nm and are used as **topical ocular drug delivery** systems [10,11], as eyedrops which make them ideal candidates for the treatment of corneal diseases. **Liposomes** are composed of one or more phospholipid bilayer membranes encapsulating a volume of aqueous medium. They deliver the active drugs to the target cells in addition to the wounded sites. **Dendrimers** are typically 1–10 nm in size [12-16], packaged with antimicrobial agents have been found to be effective against gram-negative and gram-positive pathogens often associated with lens-related bacterial keratitis [15]. **Polymeric micelles** (PMs) are self-assembled nanoparticles, ideally suited for ocular drug delivery[16,17]. **Nanoemulsions** (NEs) are nanometer droplets made by **the heterogeneous dispersions** of two immiscible liquids (oil-in-water or water-in-oil) to provide a transparent ocular drug delivery system [18]. The first FDA approval was awarded to ophthalmic nanoemulsion of Restasis (Allergan Inc., Irvine, CA, USA) for chronic dry eye conditions. In 2008, the FDA approved another similar nanoemulsion formulated drug called Durezol (Alcon Laboratories, Fort Worth, TX, USA) for the treatment of ocular inflammation. Similarly, two other products, a drug-free nanoemulsion called Lipimix (Tubilux Pharma, Italy) and Soothe XP Emollient (Bausch and Lomb, Rochester, NY, USA), have been used for the restoration of the lipid layer of the lacrimal fluid [19].

3. CONCLUSION:

The future of corneal nanomedicine greatly depends on **the innovative design and smart packaging of nanoparticles better suited for sustained drug-delivery in the eye.** It will revolutionize the way **we diagnose, monitor and treat corneal diseases** by **eliminating the need for repeated applications to achieve sustained drug effect**. The idea of **"Theragonostics"** [20] where nanoparticles deliver therapy and provide disease monitoring should be looked forward to [21].

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