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2.1s Next Generation Therapeutics

CEVR Centre for Eye and Vision Research 眼視覺研究中心

The Hong Kong Polytechnic University 香港理工大學 | University of Waterloo

Clinical Translation of a Novel Anti-Microbial Therapy for Eye Infections

Principal Investigators

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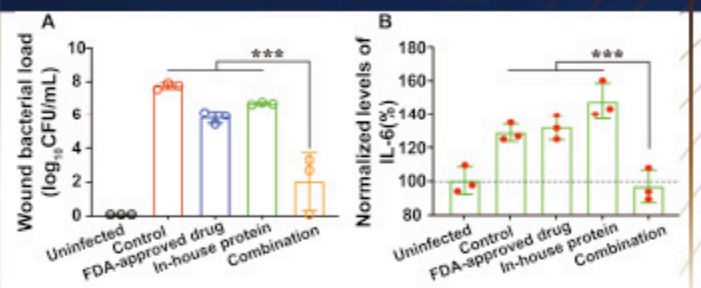
UW : Benjamin Thompson

Co-I : Chuen Thomas Lam



Combination therapy effectively relieves infection symptoms in skin infection animal models. (A) Bacterial load in wounds of infected rats (B) IL-6 level in wounds to represent inflammation, after indicated treatments for 7 days.

Aims

To complete preclinical testing and promote the translation of an innovative therapy designed to treat eye infections, addressing the urgent challenge of microbial resistance to existing antibiotic options.

Background

Antimicrobial-resistant pathogen, such as Methicillin-resistant Staphylococcus aureus (MRSA), poses a serious global health threat, especially in ocular and skin infections. Antibiotic efficacy varies due to resistance and microbiome disruption, increasing infection risks and treatment side effects. Previously, the project team discovered a combination therapy of a protein and a FDA-approved drug, enhancing antimicrobial effects over 500-fold. This therapy demonstrated excellent efficacy in animal models of ocular and skin infections.

Work to be Done

Comprehensive preclinical testing is essential to define the therapeutic index and guide future clinical trials, advancing this antimicrobial combination therapy toward regulatory approval and clinical use. Key tasks include:

- **Efficacy & Safety Testing** : Assessing treatment effects through bacterial load, ocular injury scores, immune response markers, and toxicity studies.
- **ADME Testing** : Evaluating drug absorption, distribution, metabolism, and excretion by analysing plasma and tissue concentrations.
- **Pharmacokinetics (PK) Studies** : Determining PK parameters after topical administration in mice.
- **Next-Generation Drug Development** : Building on prior CEVR research, the team aims to optimize the therapy through rational drug design, and drug repurposing, by leveraging the unique molecular mechanisms we discovered.

Benefits

Effective eye disease therapies reduce vision loss and ease healthcare burdens, especially for aging populations. The potent anti-infection treatment alleviates suffering, lowers resistance, costs, and hospital admissions. Long-term, policy-driven stewardship strengthens global health strategies and sustains effective treatments.

Impact

By repurposing FDA-approved treatments, the novel therapy accelerates drug development, reduces costs, and will potentially generate a sustainable R&D pipeline. The long-term impact includes better public health, lower healthcare costs, and improved treatment options for drug-resistant infections.

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An Organoid Platform and Cell-Based Platform for Ocular Therapeutic Development

Principal Investigators

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Rapid and affordable ocular drug development

Aims

To develop ocular organoids and cells-on-a-chip models that can be marketed to pharmaceutical companies to enable rapid and low-cost testing of new therapeutics.

Background

The FDA's decision in 2023 to eliminate animal testing requirements for clinical trials has accelerated the adoption of advanced in-vitro models, with organoids emerging as ethical and cost-effective alternatives. However, conventional in-vitro cell culture methods often struggle to replicate the complex structure, physiological functions, and biochemical environment of the human eye, highlighting the need for more sophisticated approaches. The Organoid Platform and Cell-Based Platform represents a breakthrough in vision science, leveraging microfluidics and tissue engineering to provide a more accurate simulation of ocular conditions, enabling precise investigations into ophthalmic pathogenesis and supports early-stage drug development, driving a transformative shift in research methodologies.

Work to be Done

Up to three organoids will be developed: retina, cornea and lens. **Retina**: Enhance iPSC differentiation into retinal ganglion cells using biomaterials mimicking the extracellular matrix. Conduct multiomics analysis to assess retinal organoid formation and test genetic variants and therapies for high myopia. **Cornea**: Develop corneal and lacrimal gland organoids, optimizing growth methods to reduce production time. **Lens**: Create transparent lens organoids for anti-cataract drug screening and presbyopia prevention. These organoids will enter the market to enable rapid testing of drug candidates for prevalent ocular conditions including myopia (retina), dry eye disease (cornea) and cataracts/presbyopia (lens). **Cells-on-a-Chip**: Develop a model to simulate dry eye conditions using human corneal epithelial cells and immune cells to test drug efficacy, retention, and protection. This system will enable rapid screening of novel compounds.

Benefits

This project revolutionizes organoid development with microfluidic technology, enabling scalable, high-throughput, and cost-effective production of retina, cornea, and lens models. By reducing differentiation time and ensuring uniform organoid sizes, it enhances consistency and reproducibility. The system supports simultaneous organoid generation, minimizes reagent consumption, and integrates vascular structures and immune cells via co-culture, making models more physiologically relevant for studying complex biological processes and advancing drug screening.

Impact

The development of organoids will significantly enhance ocular technology research, providing valuable models for testing new devices and innovations. This process will also deepen scientists' understanding of ocular biology, leading to advancements in drug delivery materials and techniques. Successfully establishing organoid technology will position the centre as a consultancy service, attracting industry collaborations, as evidenced by strong commercial interest from pharmaceutical companies and hospitals.

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Developing Next-Generation Therapeutic Agents for Glaucoma

Principal Investigators

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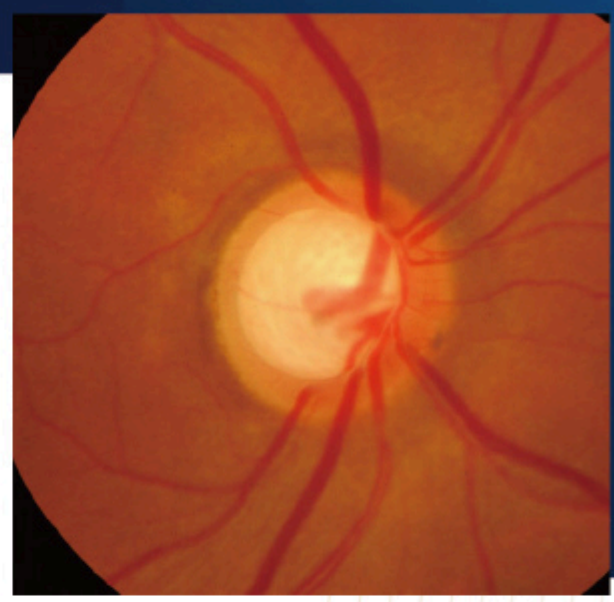
InnoHK collaboration: Centre for Chinese Herbal Medicine Drug Development



Enhanced treatment of glaucoma

Aims

To bring next-generation therapeutics for glaucoma to human clinical trials the results of which will enable commercialization by pharmaceutical and food supplement companies.

Background

Glaucoma is the leading cause of irreversible blindness worldwide. It is incurable and typically characterized by raised intraocular pressure (IOP) ultimately leading to total blindness. Lowering IOP is the only clinical intervention documented to be effective in delaying the progression of glaucoma. However, existing anti-glaucoma treatments have substantial contraindications, undesirable side effects, and drug resistance.

Work to be Done

The research team is advancing glaucoma treatment through three innovative approaches:

- **Baicalein-Based Therapy** – The flavonoid baicalein has demonstrated IOP-lowering and neuroprotective properties in in vivo and in vitro models, offering dual therapeutic benefits absent in current treatments.
- **Dietary Supplement Development** – The project integrates Nephrokin, a patented plant extract into Bao Ming Drink, a best-selling Amway product known for supporting eye health.
- **TCM-Based Prescription (TP)** – Oral administration of TP has improved retinal and visual functions in animal glaucoma models. In collaboration with the **Centre for Chinese Herbal Medicine Drug Development**, the team is optimizing its composition, dosage, and delivery for glaucoma treatment.

Benefits

This new glaucoma treatment will provide immediate relief for diagnosed patients while equipping eye care professionals with more effective intraocular pressure control options. Individuals at high risk will gain prophylactic benefits, and the biotech industry will experience growth through emerging market opportunities. Long term, the treatment is expected to reduce global glaucoma-related complications, lower healthcare costs, and improve vision outcomes for millions, benefiting public health systems and society at large.

Impact

The project introduces a new class of anti-glaucoma drugs that combine IOP reduction with neuroprotective and anti-inflammatory properties, addressing a critical gap in current therapies. Flavonoid-based treatments and advanced drug delivery systems significantly enhance effectiveness. Additionally, the study explores natural compounds, dietary supplements, and TCM formulations, offering alternative retinal protection solutions where none currently exist, creating new therapeutic classes that go beyond conventional interventions to transform ophthalmic care.

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Novel Gene Delivery Platforms for the Treatment of Ocular Disease

Principal Investigators

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UW : Roderick Slavcev

Co-I : Shea-ping Yip

Gene therapy using nano technology

Aims

To develop, validate and commercialize a redosable system to deliver DNA minivectors to the eye to enable gene therapy for ocular diseases.

Background

Delivering DNA to the eye presents a significant challenge in gene therapy and formulation chemistry, particularly due to the limitations of topical eye drops. While eyedrops are effective for treating conditions in the eye anterior segment, they fail to reach the posterior segment, highlighting a critical unmet need in ophthalmology. To address this gap, the development of targeted delivery systems capable of overcoming ocular barriers and reaching the eye's interior is essential opening new possibilities for ophthalmic care.

Work to be Done

The team will design and characterize novel delivery systems. The platforms are expected to offer neuroprotection, photoreceptor targeting, and where pertinent, fusogenic activity with the aim of enhancing safety and efficacy and potentiate redosing and titratability. Initially targeting Stargardt Disease, this platform could later be extended to other inherited retinopathies and macular degenerative disorders. Three platforms will be developed, of which one, a patented technology will use Mediphage Bioceuticals's msDNA™ minivectors. Two novel platforms involve the use of bacteriophages and anelloviruses components as nonimmunogenic targeted delivery vehicles. The overall aim to overcome the limitations of current gene therapy vectors, offering innovative, versatile, and effective therapeutic solutions for currently untreatable ocular diseases.

Benefits

A redosable and efficacious system of delivery would revolutionize gene therapy. Through this work, a biotech startup is already being assembled and will gain a competitive edge through gene therapy advancements, attracting investment and validating novel delivery methods. As technology matures and if it eventually receives regulatory approval, more patients with ocular and genetic diseases will access treatments, reducing disease burden. In the long term, gene therapy using this platform will integrate into routine clinical practice as a titratable approach to personalized medicine, improving patient outcomes and quality of life for patients. Key metrics: Startup growth, patient access, regulatory approvals, and clinical adoption rates.

Impact

Current gene therapy methods face major limitations. Viral vectors, though effective, cannot carry large cargo, are non-redosable, and pose risks like toxicity, insertional mutagenesis, and off-target effects—especially in the liver. Their high production costs also make treatments prohibitively expensive. Subretinal delivery, the standard route, is highly invasive, while intravitreal injection, though less invasive, is more immunogenic and still non-redosable. These challenges highlight the urgent need for safer, more effective, affordable, and redosable gene therapy solutions.

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Integrated Dry Eye Diagnosis and Precision Therapies

Principal Investigators

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UW : William Ngo

Co-I : Lei Henry Zhou, Chi-wai Do, Ming-yan Allen Cheong, Qian Zhao, Daisy Zhao, Samantha Shan, Simon Lee, Benqin Tang, Liping Zhou, ShuJun Wang, Maud Gorbet, Lyndon Jones, Juewen Liu

Reduced burden of dry eye disease

Aims

To develop innovative diagnostic and therapeutic technologies for dry eye disease (DED) through a multidisciplinary approach, paving the way for evidence-based, precision diagnostic modalities for DED.

Background

DED is a multifactorial ocular condition that affects up to 50% of the global population. It is not only a debilitating condition that causes eye pain and discomfort, but it also imposes a significant burden on the healthcare system. Although inflammation and oxidative stress are known to play key roles in its etiology, current treatments do not comprehensively target these underlying causes. There is still no effective and specific formulation available to treat the underlying causes of DED with minimal side effects.

Work to be Done

Researchers will advance DED diagnostics and treatment through innovative methods. Molecular diagnostics will employ SNAT2-specific corneal staining with aptamer-based technology to improve accuracy. A portable device featuring AI-assisted clinical diagnosis will be developed using Chinese-specific meibography images. Tear proteomics and lipidomics analysis will identify novel molecules, paving the way for point-of-care panels to monitor disease progression. Treatment research will leverage next-generation mass spectrometry to map nearly 9,000 corneal endothelial cell proteins and establish a mammalian model for DED-induced tear proteome studies to test traditional Chinese medicine (TCM), natural supplements, and light therapy.

Benefits

Patients suffering from DED will immediately benefit from improved diagnosis and treatment. The technology will also benefit healthcare professionals seeking improved diagnostic tools and therapies.

Impact

The team will closely observe the work plan for Regulatory Innovation and Development of Pharmaceutical and Medical Devices in the Guangdong-Hong Kong-Macao Greater Bay Area and seek approval from regulatory bodies such as the NMPA in China. Improved diagnosis and treatment for DED will benefit patients and healthcare professionals, with regulatory approvals expanding access. Collaboration between universities, research institutions, and pharmaceutical companies will drive innovation, leading to better patient outcomes, enhancing healthcare efficiency and reducing costs through targeted treatments, ultimately lowering the burden of DED.

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Development of Ocular Inserts and Aptamer-Based Delivery Vehicles for Sustained Release of Ocular Therapeutics and TCM Products

Principal Investigators

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UW : Juewen Liu

Co-I : Lyndon Jones, Chau-Minh Phan, Franco Leung Liping Zhou

InnoHK collaboration : Centre for Chinese Herbal Medicine Drug Development

Improved delivery of drugs and TCM formulations to the eye

Aims

Develop two synergistic drug delivery systems for treating dry eye disease (DED): one utilizing aptamers and the other using ocular inserts, while also discovering new therapeutic agents derived from traditional Chinese medicine (TCM).

Background

The eye's complex physiology and anatomy challenge effective drug delivery to both anterior and posterior segments. Advanced drug delivery methods are needed for better compliance and efficacy.

Work to be Done

Preclinical animal studies will evaluate the efficacy and safety of liposomes engineered with cornea-binding aptamers to deliver an established drug for DED. A pilot scale-up study will test the efficacy and safety with other dry eye drugs and TCM compounds. Success will lead to extending the aptamer-based delivery to the posterior eye segment. Ocular inserts will be developed with biomaterials that can degrade upon exposure to tear film elements or external triggers like cysteine/glutathione or phosphatase in the tear film, and evaluated for biocompatibility, degradation kinetics, handling, and safety using in vitro models. Incorporation of ocular inserts with drugs, aptamer-based delivery vehicles, and TCM will also be explored. The cell-on-a-chip device (developed in RP2.2s) will be used to screen TCM decoctions, herbs, or active compounds selected per the Pharmacopoeia of the People's Republic of China for effectiveness against DED, compared to conventional treatment. This will result in the first-ever Natural Drug Candidate Compilation for dry eye treatment.

Benefits

The combination of these therapies will offer comprehensive treatment for both immediate symptoms and long-term management of DED, significantly benefiting patients with this highly prevalent condition by providing more effective treatments that reduce side effects and improve quality of life. Healthcare providers will gain access to advanced treatment tools, enhancing patient care and reducing costs. Pharmaceutical companies will benefit from the drug database and delivery platform, fostering technology transfer and commercialization. Collaboration with Traditional Chinese Medicine (TCM) practitioners will promote TCM globally and provide evidence-based treatments.

Impact

Advancements in ocular drug delivery and screening will improve treatments for various eye conditions. Patients with posterior segment diseases like diabetic retinopathy and macular degeneration could benefit from new treatments using aptamer-based delivery systems.

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