

Evaluation of Eye Drops Containing Carbon Quantum Dots in Mice with Dry Eye Syndrome

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Abstract

Dry eye syndrome is a common eye disease (DES), variant therapeutic agents for effectively DES treatment is demanded. Carbon quantum dots (CQD) can not only prevent the fibrillation of type I collagen fibers but also be used to treat floaters by destroying collagen fibers in eyes, it's shown the potential of CQDs applied in ophthalmology. CQD also revealed anti-bacterial and anti-inflammatory effect; therefore, it shows the potential for using CQD for relief the ocular inflammation of DES.

In conclusion, the intraocular pressure in all eye drop groups had no significant change. The CQD-2 treated eyes showed the best therapeutic effect of all groups with marked increase in tear production, less damaged cornea. The thickness of the cornea is observed to be very similar to the normal group. Overall, the use of CQD contained eyedrops with a concentration of 250 µg/mL shows the potential as a therapeutic agent for treating DES.

KEYWORDS: Carbon Quantum Dots (CQD), Nanoparticle, Dry Eye Syndrome (DES)

Introduction

To explore novel approaches for treating dry eye syndrome, we have employed carbon quantum dots as a new type of therapeutic agent. Carbon quantum dots are a type of nanomaterial with numerous carboxyl groups on their surface, which impart excellent water solubility and biocompatibility. Additionally, they possess anti-inflammatory properties. Utilizing nanoscale medication in the form of eye drops represents a innovative alternative treatment strategy for ocular disorders. Nanoscale medication offers prolonged retention, enhancing drug concentration on the ocular surface and facilitating effective therapeutic outcomes. Applying this approach to the treatment of dry eye syndrome aims to evaluate its feasibility in alleviating clinical symptoms on the ocular surface.

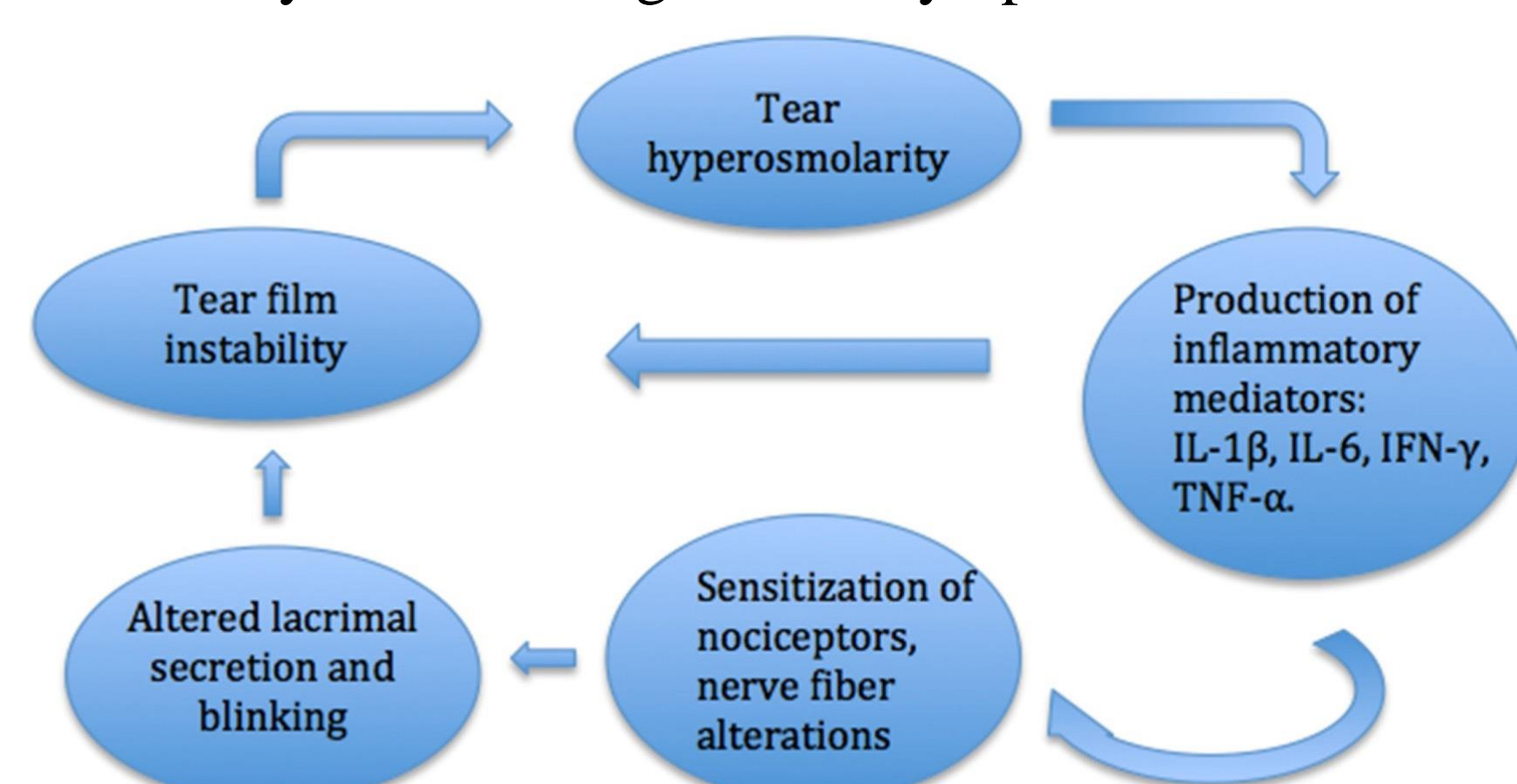


Fig.1 Formation of dry eye syndrome

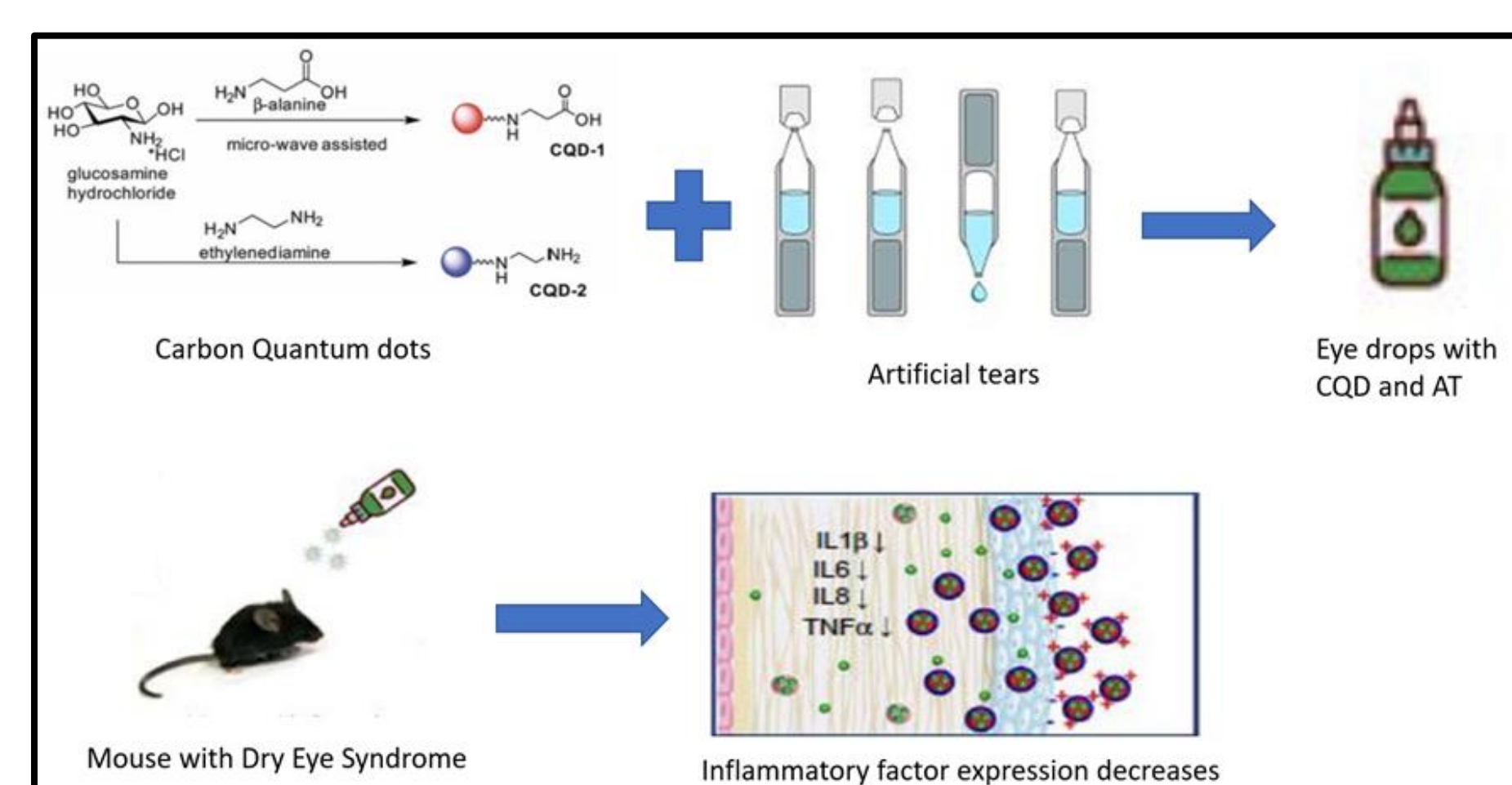


Fig.2 Experiment flow chart

Experimental Design

The CQD was adjusted to variant concentration as eye drops for used in animal test. A benzalkonium chloride (BAC) induced DES mouse model was created, CQD contained eye drops was drop on mice eye once daily. There were 4 tested groups performed : (1) Normal group (without any induction and treatment) (2) PBS group, (3) CQD-1 group (CQD: 25 µg/mL), and (4) CQD-2 group (CQD : 250 µg/mL). The treatment was lasted for 21 days, and the clinical symptom (tear volume, fluorescent stain of cornea, intraocular pressure) of DES were analyzed during the stationary period. And histological examination of whole mice eyeball was also proceeded.

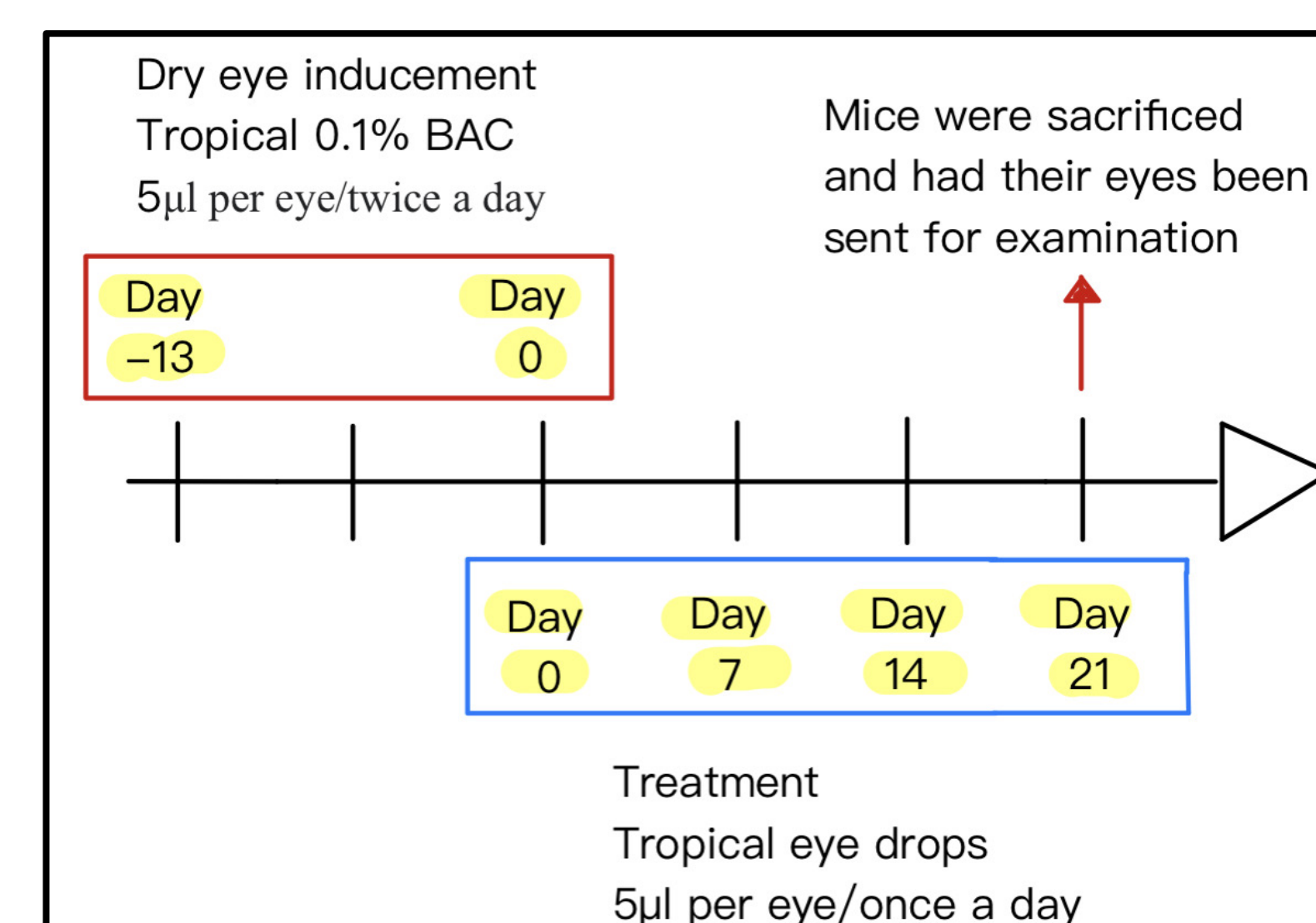


Fig.3 Measurements of tear production, IOP, and photography of eyes

Results & Future Works

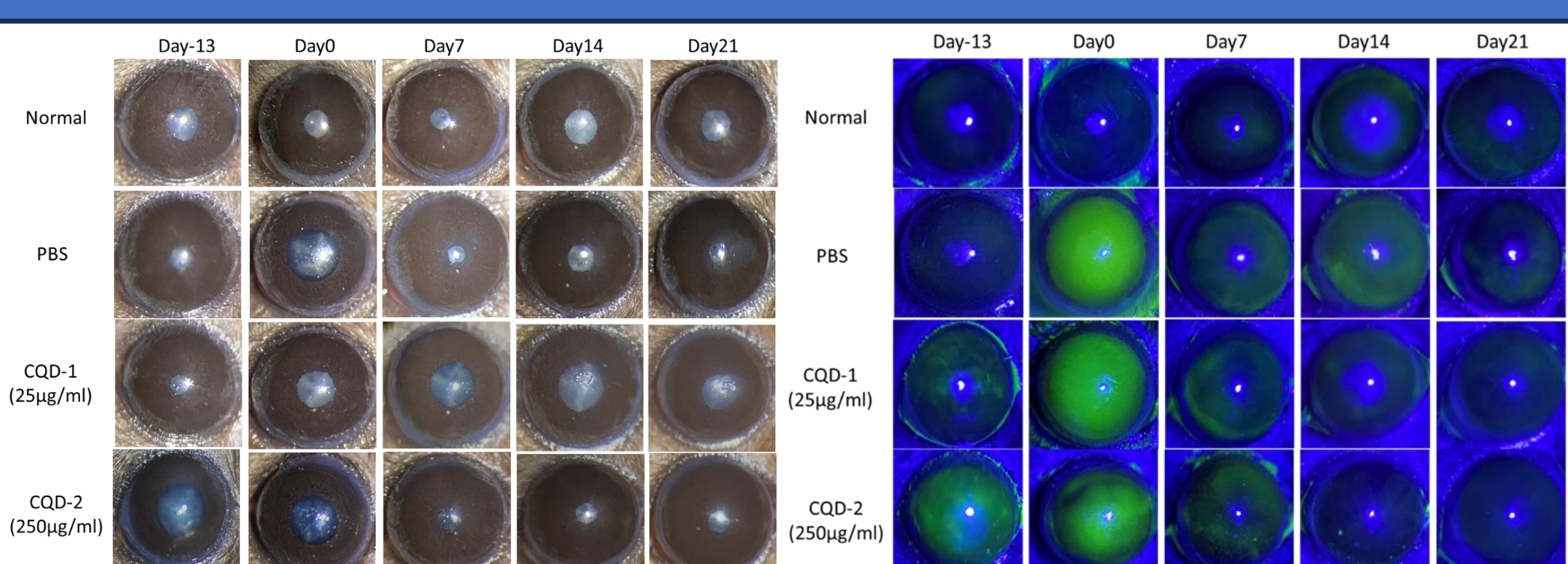


Fig. 4 Ocular surface observation results

Fig. 5 Corneal fluorescein staining results

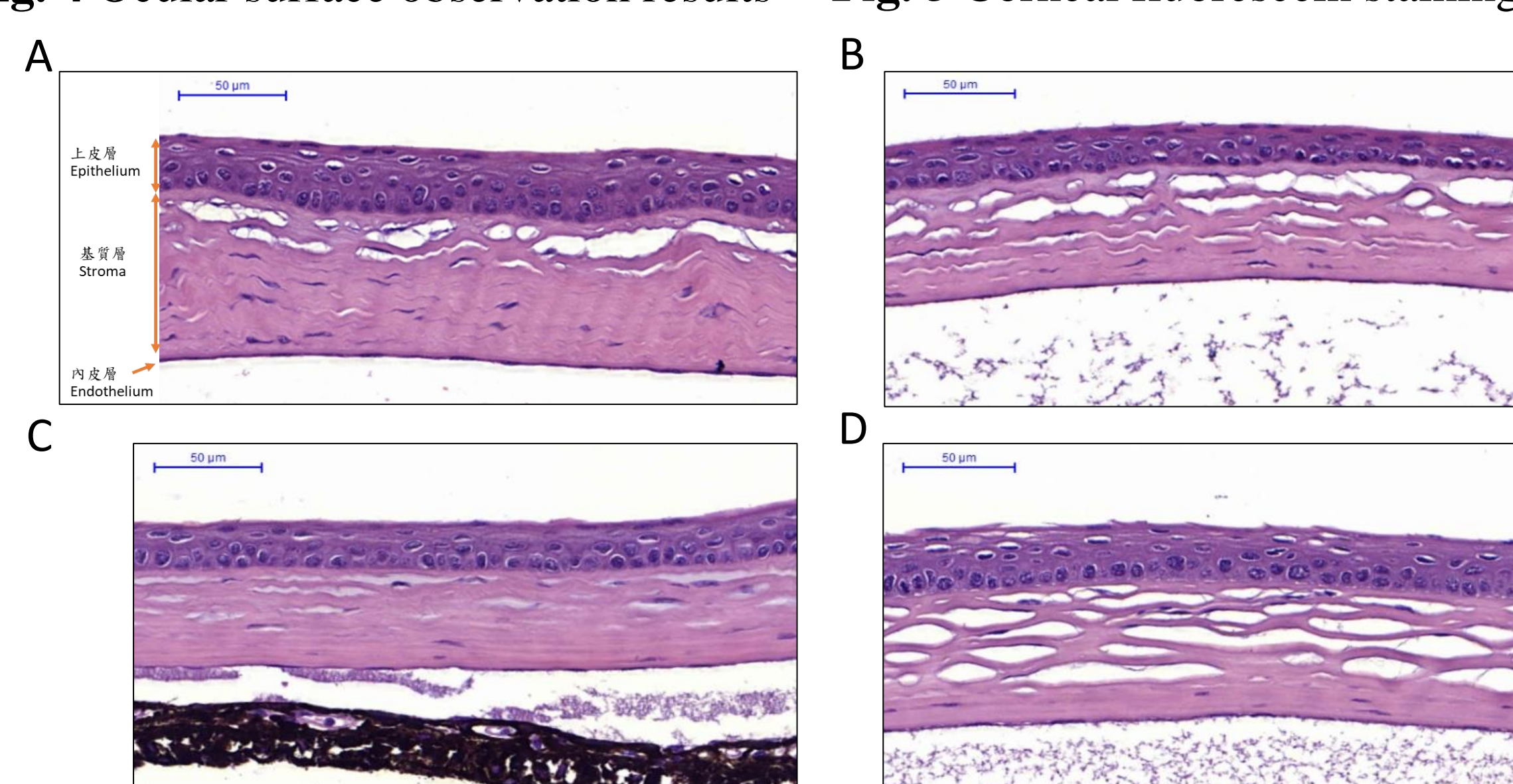


Fig. 6 H&E Staining results; (A) Normal (B) PBS (C) CQD-1 (D) CQD-2

All groups of eye drops did not result in additional adverse effects due to changes in intraocular pressure. Among all the groups, the CQD-2 group exhibited the most favorable treatment outcomes. In addition to a significant increase in tear secretion, during the treatment course observed under blue light slit-lamp microscopy, the corneas of mice in the CQD-2 group gradually recovered each week. Corneal thickness measurements indicated a thickness similar to that of the Normal group. Based on the experimental results, using eye drops containing carbon quantum dots at a concentration of 250 µg/ml has demonstrated the anticipated therapeutic effects for treating dry eye syndrome.

It was observed that using eye drops containing a mixture of carbon quantum dots and artificial tears could suppress the expression of inflammatory cytokines (IL-1β, IL-6, and TNF-α). The success of this experiment demonstrates that in the future, novel eye drops containing carbon quantum dots could overcome the shortcomings of existing methods on the market.

Reference

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