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MULTIFUNCTIONAL COLLAGEN CORNEAL SHIELDS ENABLING SUSTAINED DRUG DELIVERY AND REGENERATION FOR OCULAR SURFACE THERAPY

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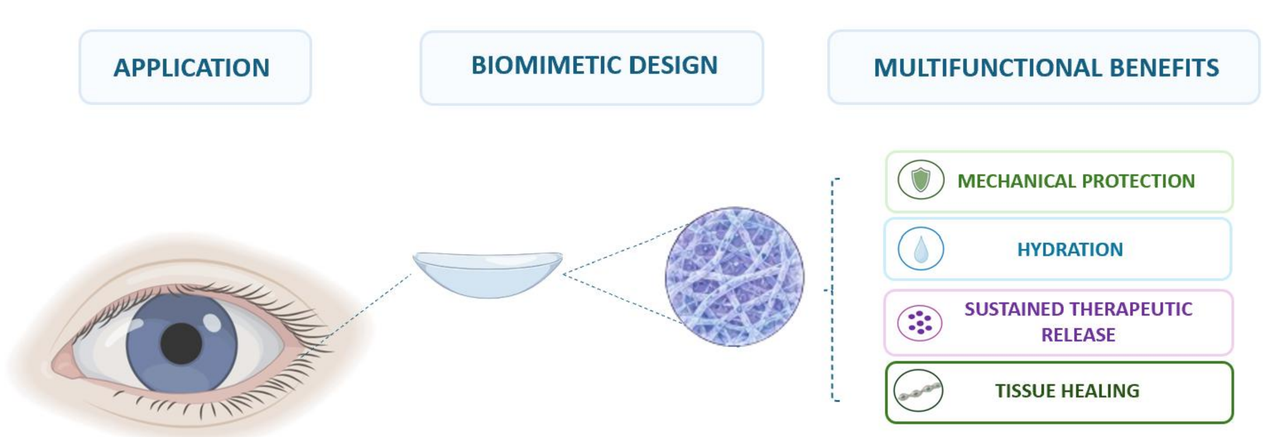
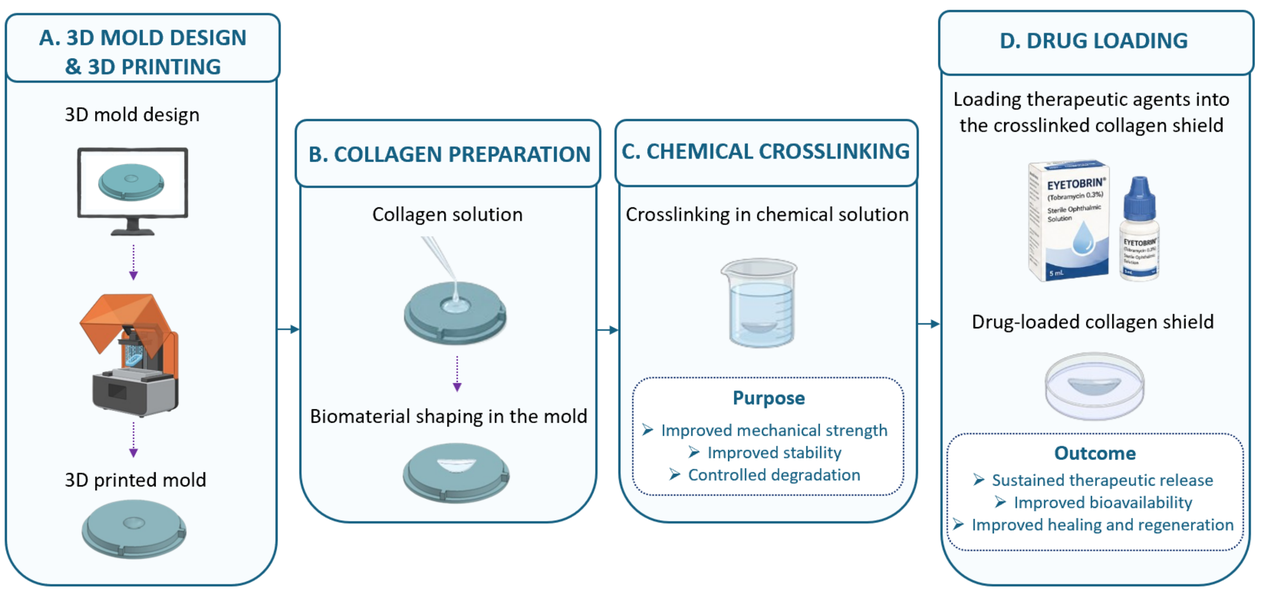
INTRODUCTION & AIM

Regenerative medicine in ophthalmology offers a novel approach to overcoming the limited healing capacity of ocular tissues and the challenges of conventional therapies. Ocular drug delivery remains hindered by physiological barriers, including tear turnover and the protective corneal epithelium, leading to the loss of up to 95% of topically administered therapeutics via conventional eye drops. Consequently, there is an urgent demand for biomaterial scaffolds that can retain therapeutics on the eye longer while helping tissue repair. In this context, collagen-based corneal shields have emerged as a promising multifunctional drug delivery platform biomimetically resembling the native corneal extracellular matrix. Beyond mechanical protection and hydration, they offer sustained drug release and function as temporary scaffolds to promote corneal healing. The present study investigated the development of therapeutic, chemically crosslinked collagen corneal shields fabricated using custom-designed 3D-printed molds and evaluated their physicochemical, optical, rheological, degradation, and drug-delivery properties to assess their potential as next-generation scaffolds for regenerative ophthalmic applications.



METHOD



CONCLUSIONS

Collagen corneal shields fabricated using 3D-printed molds showed high optical transparency, controlled degradation, sustained drug release, and favorable viscoelastic properties. These results highlight the potential of collagen corneal shields as multifunctional biodegradable scaffolds for regenerative ophthalmology, while further in vivo studies are warranted to assess their long-term ability and clinical translation.

FUTURE WORK

- Incorporate nanoparticle technology into the shields to achieve controlled, customizable, and therapeutically tailored drug release profiles.
- Measure oxygen permeability in accordance with ISO standards to ensure corneal oxygenation and long-term ocular health.
- Perform in vivo studies to validate long-term safety, biocompatibility, and clinical performance.
- Explore manufacturing scalability, reproducibility, and cost-effectiveness to bridge the gap between laboratory research and clinical application.

RESULTS & DISCUSSION

High Optical Transparency

- Visible-light transmittance exceeded 90%, satisfying ophthalmic transparency requirements and maintaining visual acuity.

Controlled Degradation

- Corneal shields showed predictable biodegradation with 5–25% mass loss.
- Higher collagen and crosslinking concentrations reduced dissolution rates and improved structural stability.

Improved Mechanical Properties

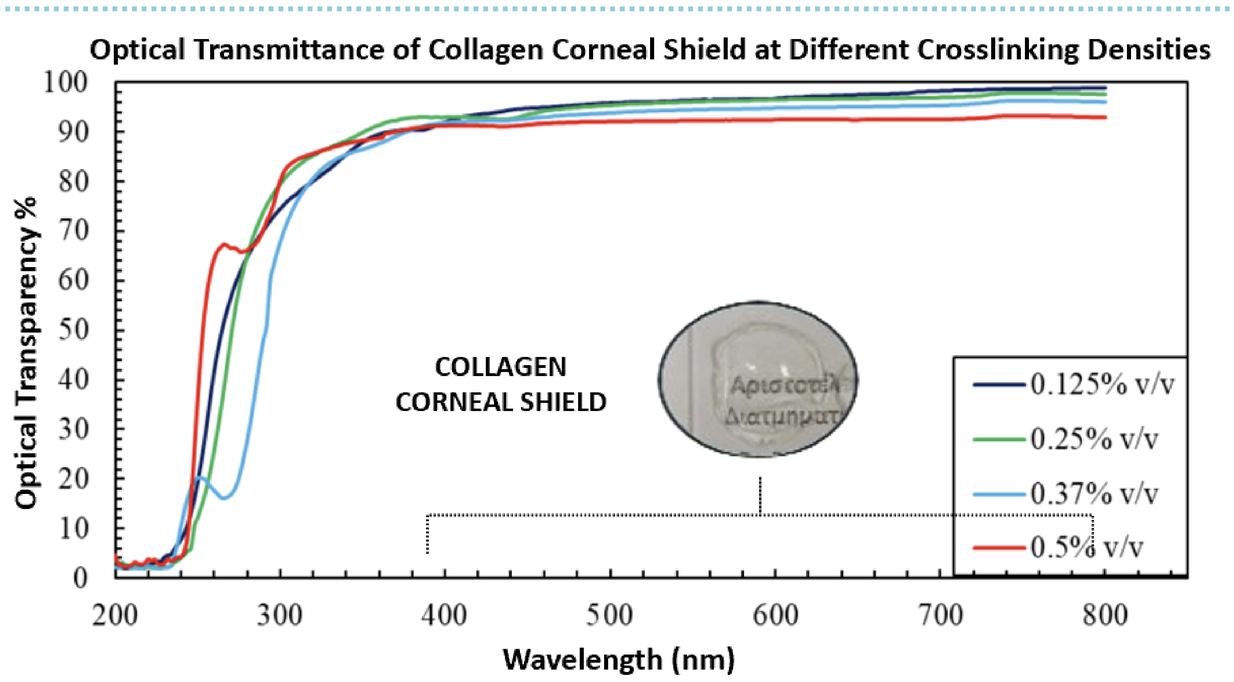
- Increased collagen and crosslinking density resulted in higher storage modulus (G') values.
- All formulations showed predominantly elastic behavior (G' > G"), verifying the formation of stable hydrogel networks.

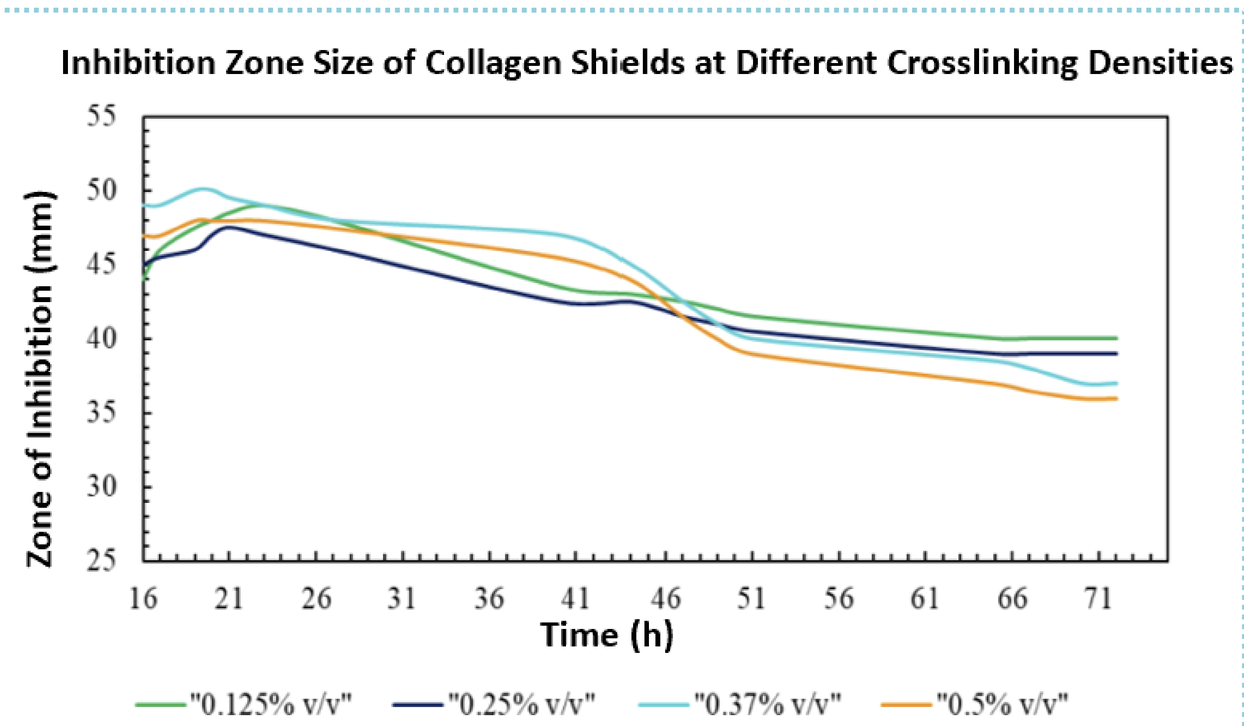
Sustained Drug Delivery

- Tobramycin-loaded shields maintained antimicrobial activity for up to 72 h, proving their capability for effective drug incorporation and sustained release.
- Higher collagen and crosslinking concentrations reduced burst release and promoted prolonged drug diffusion.

Clinical Potential

- Custom 3D-printed molds enabled the fabrication of transparent collagen corneal shields with controlled degradation, sustained therapeutic delivery, and favorable mechanical properties.
- These findings highlight their potential as multifunctional biodegradable platforms for regenerative ophthalmology and advanced ocular drug delivery.





RELATED REFERENCES

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- Rykowska, I., Nowak, I. and Nowak, R. (2021) 'Soft contact lenses as drug delivery systems: A Review', Molecules, 26(18), p. 5577. doi:10.3390/molecules26185577.