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Editorial

ARVO 2017 highlights in mathematical modeling

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At the ARVO annual meeting, the contributions that involve significant mathematical modeling of ocular physiology and procedures is on the increase. There has long been significant use of statistical methods for understanding data from a variety of uses such as *in-vivo* measurements and human trials of various sorts. Beyond those important uses of statistical and mathematical tools, a growing number of researchers are developing mathematical and computational models, often based on fluid and solid mechanics principles, that provide insights into ocular phenomena. A number of areas had noticeable contributions involving applications of models, such as tear production, tear film dynamics, corneal biomechanics, retinal blood flow, and glaucoma. We list a number of such contributions in this introduction, and five extended abstracts summarize some of the studies mentioned here.

Corneal biomechanics was an active area. The contribution from Francis and coworkers[1] sought to quantify the eect on the changes to corneal biomechanics due to incisions and subsequent healing from SMILE and FS-LASIK procedures using finite element modeling in an inverse problem approach. A contribution from Mengchen Xu and coworkers[2] sought to estimate collagen fibril properties using an inverse problem approach. Seven and coworkers[3] used a finite element method to study outcomes of post-PRK corneal tomographies. In this issue, there is a an extended abstract from Pinsky and coworkers[4] that develops a simple yet eective continuum model for the collagen fiber arrangement in the stroma. The model fits wide angle x-ray scattering data from both normal and keratoconic human corneas. The model does a good job of capturing orientation dependence, and is suitable for use in finite element modeling the cornea. The model could enable significant insights into keratoconus, among other corneal phenomena.

Contributions using fluid mechanics approaches included models fromthe retina to the ocular surface. There were a number of papers studying mathematical

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blood flow in the retina related to glaucoma and other pathologies. These include two efforts described in this issue. Sacco and coworkers[5] studied the eect of nitric oxide on the neurovascular coupling to regulate blood flow in the retina using a compartment model. Sala and coworkers[6] investigated a mathematical model of the blood flow in the lamina cribosa and retina that combined porous medium and compartment models that can be tailored to specific patients. An extended abstract in this issue briefly discusses results from these two projects. Another patient-specific modeling approach was presented by Krishnan *et al.*[7] that used finite element methods to compute mechanical response of the optic nerve head to, *e.g.*, various values of intraocular pressure. Incorporating realistic properties into such modelswas the focus of the study of Grytz *et al.*[8]

Moving forward into the posterior chamber, Repetto and coworkers[9] presented results on finite element models for the stresses generated on the retina as vitreous fluid detached fromthe posterior side. Thework identified shapes of vitreous detachment that could generate large tractions on the retina.

At the ocular surface, the tear supply was of interest. Radke *et al.*[10] developed a relatively simple ordinary dierential equation model that recovered experimentally observed profiles for tear production in Schirmer strips. This model clarifies interpretation of the dierent kinds of cases observed.

Two contributions studying tear film film flow are included in this issue. One is a mathematical model for imaging using fluorescein in rapid tear break up (TBU) from Lan Zhong *et al.*[11] The model hypothesized that globs of excess lipid can drive strong tangential tear film flows that promote very rapid TBU. Their fluid dynamics model simplifies glob-driven flow and fluorescence from instilled dye to just a few partial dierential equations that match observed time and space scales from *in-vivo* experiments. They find that unlike evaporatively-driven TBU, fluorescein concentra ions below the critical value were better for estimating tear film thickness for rapid TBU that takes only a second or less. Another tear film contribution is from Cwiklik and co-workers.[12] In their approach, molecular dynamics is used on the various lipid molecules of a model lipid layer atop an aqueous layer. The lipid layer includes both non-polar and polar lipid molecules so that spreading of the lipid can occur, while some aspects of the molecules, such as the hydrocarbon tails, are simplified. They found that there could be small gaps in the spreading of the lipid layer, which could promote evaporation and TBU. This work is among the very few eorts that examines the molecular arrangement of the lipid layer itself. The approach is promising for improving our understanding of lipid layer structure, and could help lead to better treatments for dry eye and other ocular surface issues.

We hope that you enjoy the extended abstracts here as much as we enjoyed learning about these and other results at ARVO 2017.

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