QUB - Mechanical and Aerospace Engineering PhD Project 2019-2020

Title: On the development of biomechanics numerical models for the prediction of shear stress distribution on human eyes

Project description:

Blinking and rubbing both apply shear stress to the cornea that is mitigated by lubrication from human tear film. Excessive shear stress can disrupt the tear film, leading to conditions such as dry eye. If sustained for long periods (e.g. due to persistent eye rubbing) shear overloading may lead to local degeneration of the cornea. One such degenerative condition that may be related to excessive shear stress is keratoconus: tissue degeneration leads to localised bulging, due to intraocular pressure, and a conic, rather than spherical, shape that disrupts the optical function of the cornea (Fig. 1).

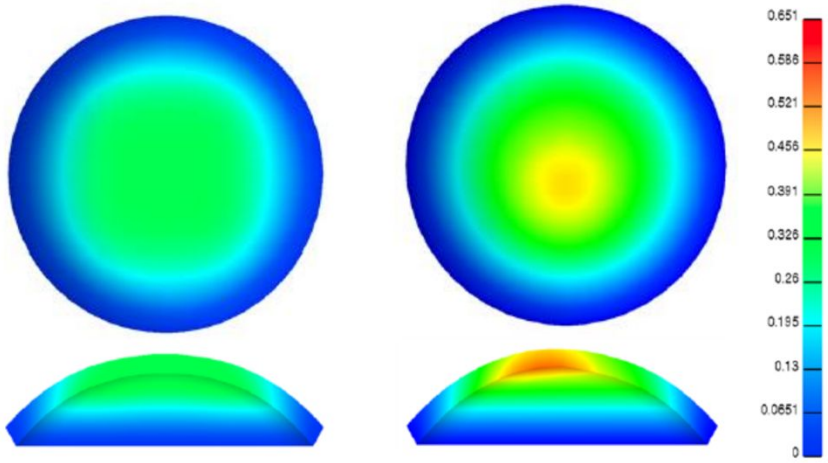

Fig. 1: Apical displacement (mm) for a healthy vs keratoconic cornea predicted by finite element analysis. Bulging of the cornea is evident below the centre of the cornea, where the tissue was given appropriate mechanical properties for a keratoconic cornea obtained from literature.

Aims and Objectives:

This research project aims to investigate and develop novel methodologies for the accurate numerical prediction of shear stresses on human eyes. Specifically, the project will focus on the development of numerical models to properly capture the interaction between the blinking of the eyelid, the tear film and the cornea itself. Ultimately, this has the potential to contribute to understanding of cornea degeneration, e.g. keratoconus, and subsequent treatment strategies.

Moreover, the PhD student will work in close collaboration with the cathedral eye clinic. This will enable better understanding of novel experimental techniques in the field and to have access to experimental data which will drive the PhD.

To achieve these goals the project has the following objectives:

1. Develop an understanding of the properties of the cornea, tear film, and of the effects of blinking.
2. Investigate the most accurate methodology to numerically characterise the solid-fluid interaction between eyelid tear-film and the cornea's surface.
3. Investigate how this interaction changes when deformations of the cornea are present (e.g. keratoconus)
4. Analyse if these changes may have a direct impact on further degeneration of the cornea.

Key skills required for the post: This challenging and interesting project requires computational, scientific, and communication skills. Applicants should have a keen interest in numerical modelling applied to biomechanics.	
Key transferable skills that will be developed during the PhD: Transferable skills that will be developed during the PhD are: i) Scientific Computing, ii) Communication to a multidisciplinary audience, iii) time management, and iv) leadership skills.	
Lead supervisor:	Name and contact details of person leading the research. Dr Marco Geron < m.geron@qub.ac.uk >
Other supervisor(s):	Name(s) of anticipated other supervisors on project Dr Alex Lennon < a.lennon@qub.ac.uk >
Guaranteed stipend:	£15,009
Conditional top-up available:	
PhD students in the School have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.	

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.