



Fighting for Sight: From Microstructure to Vision Loss - Modelling the Role of Müller Cells in Macular Hole Formation

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Aim: Use mathematical modelling to understand the development of macular holes and improve clinical treatments.

Background:

- The **macula** provides **sharp, detailed central vision**.
- **Müller cells** are **tiny fibres** that **stabilise the macula**.
- Aging causes the eye's **gel filling to shrink**, pulling on the macula, **creating a hole** and damaging vision.
- Does Müller cell shape influence hole formation?

Why does this matter?

- **1.5 million people in the UK** affected by **Macular disease**.
- Costs **£25 billion/year**, rising to **£33.5 billion** by 2050.
- **25,000 new cases annually**.
- Rising pressure on **NHS eye services**.

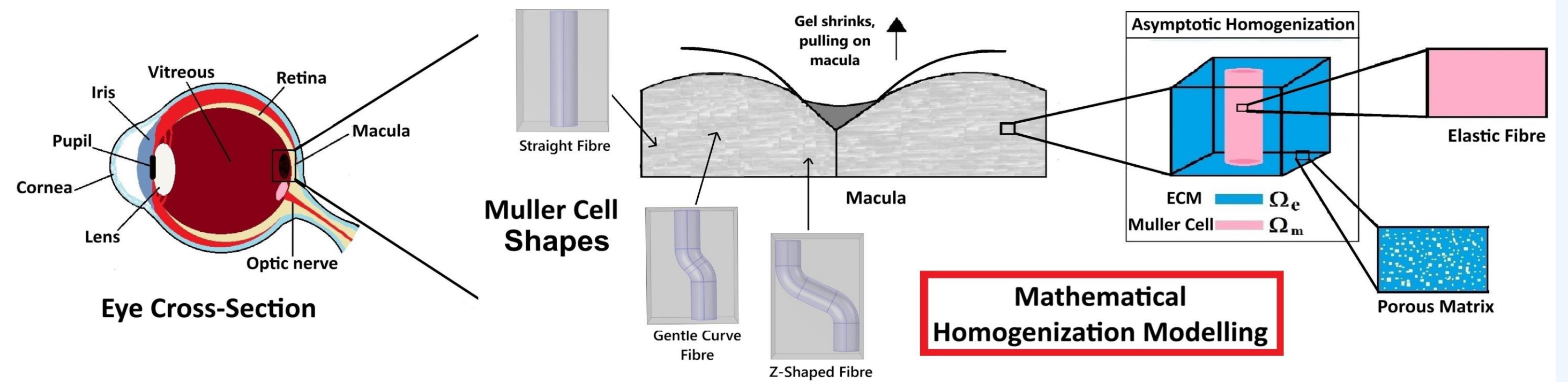
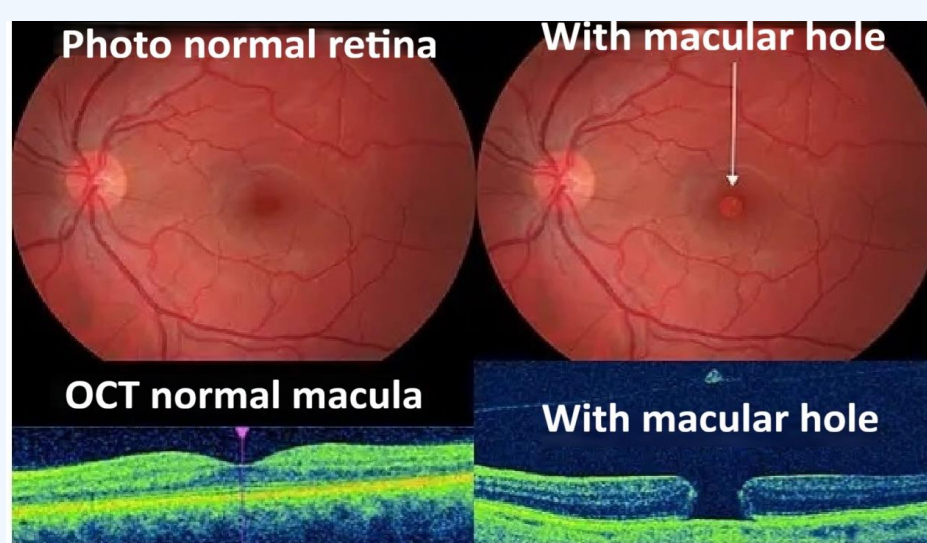
Did you know?

If you get a macular hole in one eye, there's about a **1 in 10** chance of getting one in the other eye.

Key novelty:

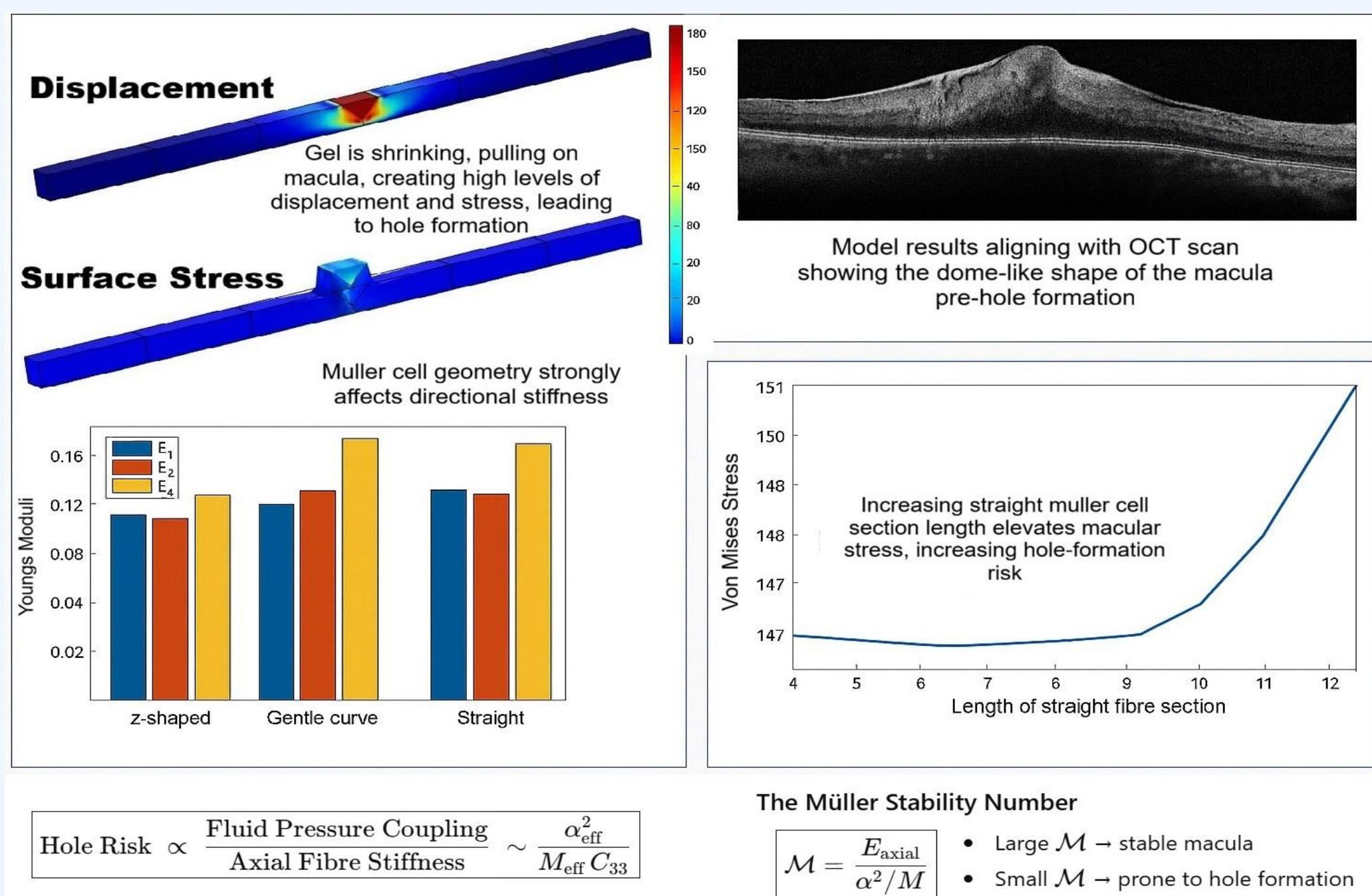
- First model linking **Müller cell shape** directly to macular stress.
- Demonstrates how cell shape **determines hole risk** via our novel **Müller Stability number \mathcal{M}** .
- Provides a **predictive framework** for clinicians.

Methods:



- 🔬 Our mathematical **homogenization** approach “**zooms out**” from microscopic details to capture the **macula's behaviour**.
- 🧩 Simplify millions of cells, retaining important physics for **precise predictions**.
- 🔗 Connect Müller shape to macular-risk, revealing **Müller cells influence macular hole formation**.

Results: Müller cell shape determines risk



- 🔪 **Straight cells** = stiffer macula, higher stress.
- 🌀 **Z-shaped cells** = best shear resistance, lower stress, greater stability, protective effects.
- ⚠️ High surface stress = higher macular hole risk.

Impacts:

- ✅ Müller Cells help **prevent sight loss** by **protecting the macula** from tearing.
- ✅ Model predictions help doctors **plan timely surgeries**.
- ✅ **Predicts at risk patients** and helps **design treatments** that strengthen the macula.
- ✅ **Reduce NHS burden and costs**.

The big message:

The **microscopic shape** of Müller cells predicts whether the **macula tears**. Our model reveals this hidden risk factor, **helping clinicians target** the right eyes at the right time.