Development of 3D-printed models of eyes with retinoblastoma as a leukocoria teaching aid

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Retinoblastoma

- Most common pediatric ocular cancer.
- Excellent disease-free survival rate in high-income countries (95-100%), poor disease-free survival rate in low-income countries (36-77%), attributed to delayed diagnosis and treatment.[1, 2]
- Increasing early diagnosis of retinoblastoma was identified as the top research priority by a Canadian Retinoblastoma Research Advisory Board workshop in 2017.[3]

- **Improving early diagnosis is critical.**

Leukocoria

- White reflection (white reflex) of light from a tumour instead of red reflection (red reflex) from the retina.
- Most common initial presentation of RB.
- Often first recognized in flash photographs by parents.[4]
- Children demonstrating leukocoria are usually first examined in family practices or emergency rooms.

- **All physicians should be familiar with the appearance of true leukocoria.**

Figure 1 Leukocoria (white reflex) in one eye due to retinoblastoma.

3D Model Eyes for Training

We are developing 3D models of eyes with retinoblastoma to be used as teaching tools for physicians-in-training.

Objectives:

- **Accurately represent the anatomy of eyes with retinoblastoma.**
- **Mimic the appearance of leukocoria through a direct ophthalmoscope and digital cameras.**

Model Development

REB approved for retrospective analysis of diagnostic imaging from RB patients

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Select ~16 eyes spanning all stages of RB

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Collect imaging data at diagnosis: MRI, CT, OCT, US, photographs

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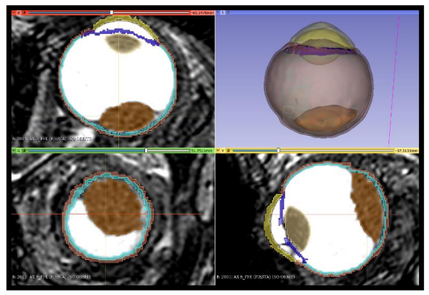
Segment MRI images to get meshes of lens, cornea, retina, tumour, etc.



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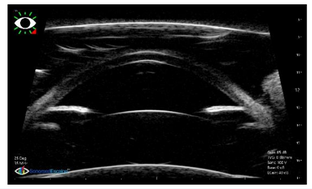
Refine meshes: data from other imaging modalities



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3D print or mould model eye components based on meshes

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Add colour in 3D printing process | **Colour painted on by hand.**

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Assemble 3D Model

First Models

First 3 eyes selected for segmentation, 1 eye fully segmented and first model eyes created.

3D Model Eye Version 1

- Iris, retina, choroid and sclera 3D-printed in soft, translucent photopolymer. Colour painted on by hand.
- Cornea in hard acrylic, no lens.
- Aqueous and vitreous humours in silicone.
- **Demonstrated leukocoria**
- **Not optically accurate**
- **Need to improve retinal detail and colour accuracy**

3D Model Eye Version 2

- Iris, retina, choroid and sclera 3D-printed. Mixed rigid, white photopolymer with translucent photopolymer. Colour painted on by hand.
- Cornea and lens moulded in clear silicone. Exploring methods to improve optical clarity.
- Exploring optimal material for aqueous, vitreous humours
- **Improved detail, colour accuracy.**

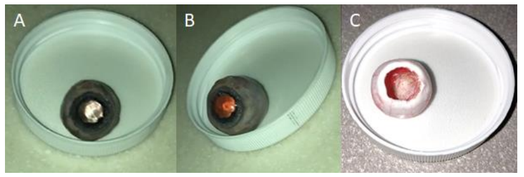

Figure 2 First version demonstrating leukocoria (white reflex) with coaxial illumination (A), red reflex with off-axis illumination (B). Retina, choroid, sclera and tumour of second version (C).

Next Steps

- Explore methods to accurately recreate fundus appearance (e.g. project fundus images on 3D mesh surface to 3D print retina/tumour detail in colour).
- Adjust materials (especially refractive index) and modeling methods for cornea/lens to accurately recreate eye optics.
- Validate models with medical student training study.

References

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