Evaluating the Impact of Refractive Error on Central Axial Length Measurements Using IOL Master 700 and Brain MRI Scans

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Purpose

Posterior retinal curvature has emerged as a promising biomarker for emmetropization [1, 2]. Traditionally, magnetic resonance imaging (MRI) has been utilized to assess ocular geometry; however, its application in clinical practice is limited [3]. This study aims to enable standard ophthalmic care devices to estimate posterior retinal curvature. As a first step, **the current work compares the central Axial Length (AL) measured by the IOL Master 700 with the MRI-derived axial length (MRI-AL)** from segmented brain MRI scans, focusing on dependence of refractive error.

Methods

A dataset on 140 eyes, left and right, was acquired by standard ophthalmic biometry and aberrometry under cycloplegia, with a spherical equivalent from -20.55 D to +5.50 D (8 dropouts due to non-completion of measurements).

Table 1: Imaging devices.

Device	Cyclopegic Parameter
Zeiss i.Profiler Plus	Aberrometry
Zeiss IOL Master 700	Axial Length

Table 2: Data overview.

Age	(29.53 ± 7.97) years
Spherical Equivalent	(-2.05 ± 3.65) D
Axial Length	[22.1, 27.3] mm

A subset of participants provided their brain MRI scans, (not taken more than 2 years prior to this study). Among these, 11 representative MRI images were analysed. From the right eye, MRI-AL was extracted.

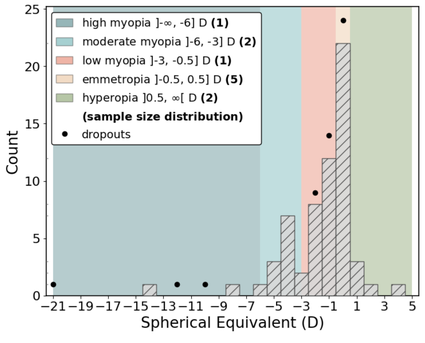

Figure 1: Spherical equivalent refractive errors of study population group. Grouped by refractive group into high myopia, moderate myopia, low myopia, emmetropia, and hyperopia. At least 1 MRI scan was analysed per refractive group, mentioned as sample size distribution.

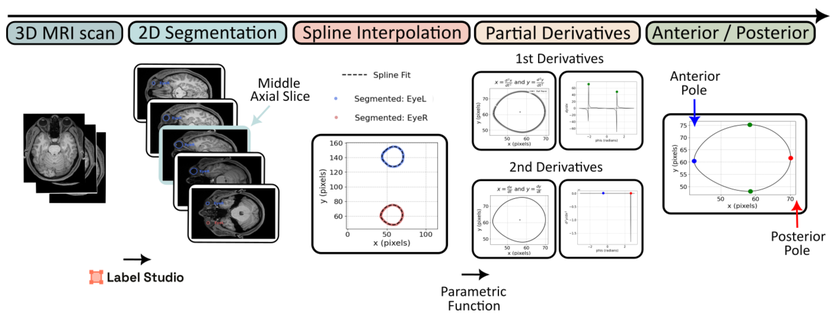

Figure 2: Pipeline to semi-automatically extract the anterior and posterior ocular poles. All scans were manually segmented using Label Studio. A parametric fit was applied to the resulting polygon annotation. Anterior and posterior pole of the eye were determined through first and second partial derivatives over the resulting parametric function. AL was estimated as the distance between the two poles and scaled according to the resolution of the scan. Code was developed with Python v.3.10.11.

Results

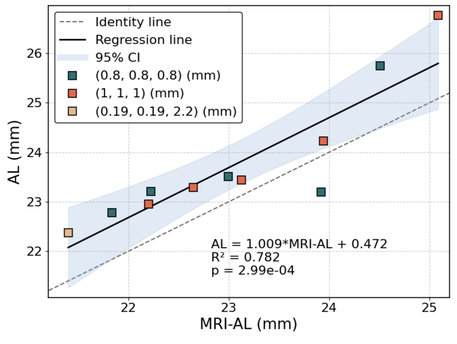

Figure 3: Correlation between AL and MRI-AL shows a strong linear relationship. Color of data points represent MRI voxel spacing (dx, dy, dz).

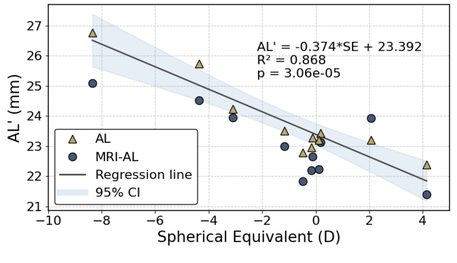

Figure 4: Linear regression model of AL and MRI-AL with Spherical Equivalent. A strong negative correlation is demonstrated (AL' = -0.360*SE + 23.317, with R^2 = 0.850).

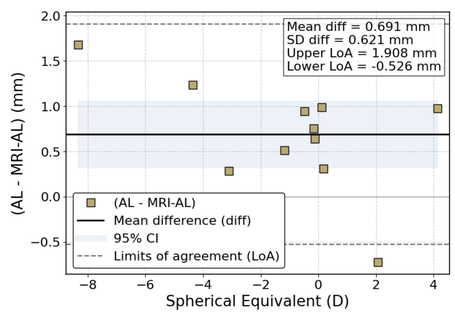

Figure 5: Bland–Altman reveals a positive mean bias for the difference between AL and MRI-AL. AL is consistently higher than MRI-AL (Mean diff = 0.69 mm, LOA varies from –0.526 to 1.908 mm). LOA indicate moderate variability, and no clear trend across spherical equivalent.

Discussion

AL and MRI-AL have been matched, an offset has been identified. Resolution of the MRI scans, and its segmentation might have contributed. In future work 3D segmentation will be applied to mitigate artefacts, such as ocular tilts in the MRI scans, and voxel resolution related effects.

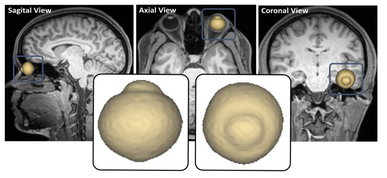

Figure 6: Example of a 3D MRI scan, and its labels. Segmented in 3D Slicer software.

Conclusion

Biometry and MRI-extracted central ALs are strongly correlated. Comparison of axial lengths between MRI and standard opthalmic biometry provides a foundation for estimating retinal curvature based on standard biometry.

References

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Disclosure: A. Rodrigues; K. Rifai; J. L. Witten; and S. Wahl (Employments: Carls Zeiss Vision International GmbH).