Machine learning-estimated axial length is better than spherical equivalent for identifying high-risk myopic eyes

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Introduction

- Myopia **increases risk of vision loss** from retinal detachment, glaucoma and myopic maculopathy[1]
- Higher risk of vision loss is **strongly associated with axial length (AL),** with a longer eye at higher risk[2]
- **Treatments to reduce axial eye growth** are available[3]
- **Identifying myopic children and adolescents** with a long axial length will ultimately reducing their risk of vision loss later in life, by enabling access to timely and appropriate myopia-control treatment

Methods

Development of the AL estimator

- A machine learning-based algorithm (AL estimator) was **trained using data on age, sex, spherical refractive error, astigmatism and corneal radius of curvature** derived from 4163 participants
  - 1626 (aged 5-13 years) from Ireland[4]
  - 2189 (aged 5-19 years from Northern Ireland[5]
  - 348 (aged 6-77 years) from South Korea[6]

Performance of the AL estimator

- The AL estimator was evaluated using data from participants of myopia-control treatment trials (3 Irish[7], 1 Australian[8])

Statistical analysis

- Right eye data were used for the analysis
- Bland-Altman statistics were used to compare estimated and actual AL.
- Receiver operating characteristic analysis was used to assess the ability of the AL estimator, compared to spherical equivalent (SE) to identify children with a high AL (≥26mm) and fast progressors (≥0.3mm axial elongation in 12 months).

Results

Table 1. Baseline characteristics of studies used to evaluate the AL estimator

Characteristics	Ireland	Australia
N	354	153
Mean (SD) age [years]	11.2 (2.4)	11.7 (2.7)
Age range (years)	6-17	6-17
n (%) female	77 (57.0%)	183 (60.6%)
Mean (SD) SE [D]	-3.21 (1.74)	-3.39 (1.17)

Irish data from Myopia Outcome Study of Atropine in Children (MOSAIC) and other studies conducted at the same institute. Australian data from Western Australian Atropine Treatment of Myopia Study (WA-ATOM). AL: axial length; SE: spherical equivalent

Table 2. Results comparing actual and estimated axial length

Results	Baseline axial length	12-month axial length change
Mean (95% CI) [mm] – biometry	24.78 (24.69, 24.86)	0.21 (0.20, 0.23)
Mean (95% CI) [mm] – AL estimator	24.85 (24.77, 24.95) *	0.21 (0.19, 0.24)†
95% repeatability coefficient	0.91 mm	0.29 mm
Lin's concordance correlation (95% CI)	0.89 (0.87, 0.91)	0.77 (0.72, 0.80)

*p < 0.001 for paired comparison of mean axial length between biometry and AL estimator
†p=0.59 for comparison of mean axial length change between biometry and AL estimator

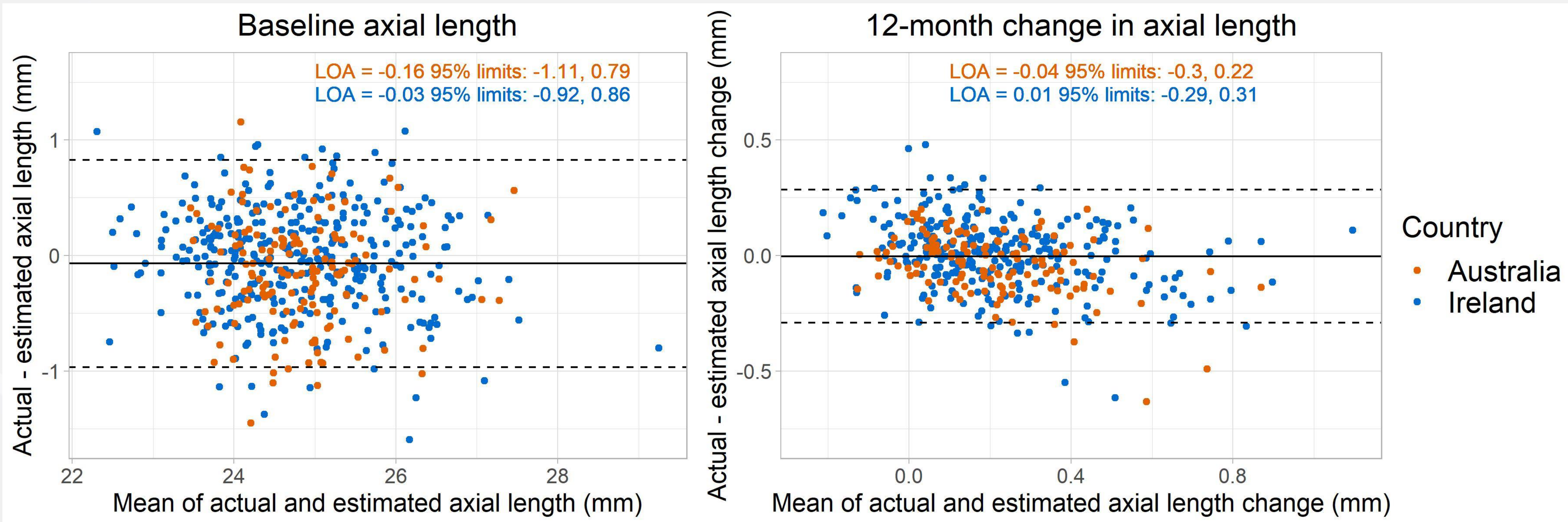

Figure 1: Bland-Altman plots demonstrating a small mean difference in axial length (AL) at baseline and 12-month change measured by biometry and using the AL estimator; LOA: limits of agreement; CI: confidence interval

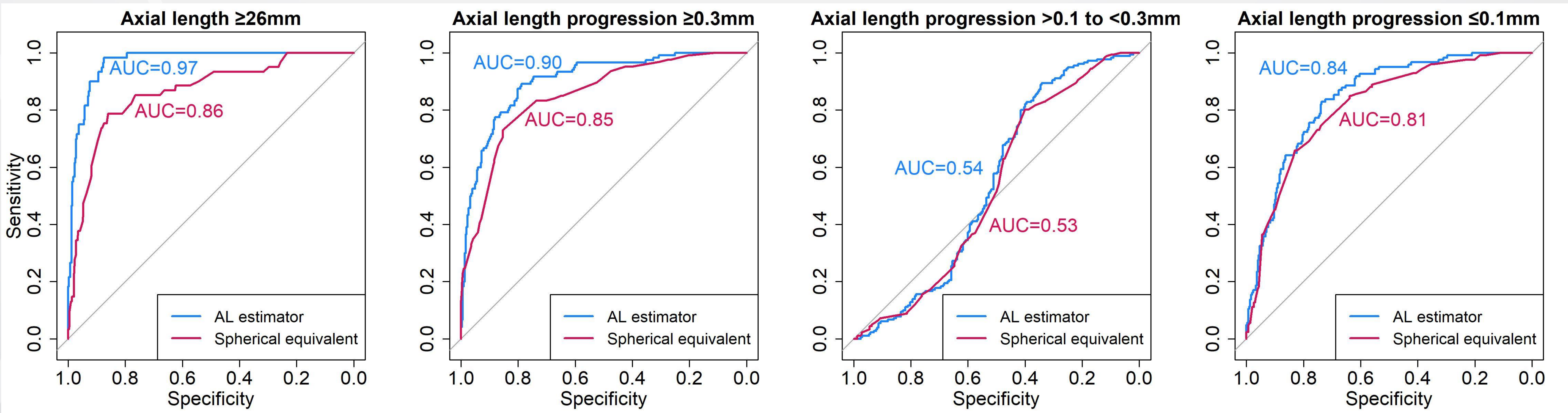

Figure 2: Receiver operating characteristics (ROC) curves showing that AL estimator was better than spherical equivalent at identifying participants with a high axial length or who had faster axial eye growth, but performed similarly at identifying mid and stable axial eye growth.

Conclusions

- The AL estimator provided a valid estimate of AL (LOA: +/- 1mm) and 12-month change in AL (LOA: +/- 0.3 mm)
- The AL estimator demonstrated **high diagnostic performance** in identifying individuals with **long AL** and those who exhibited **excessive axial elongation**, and was **better than spherical equivalent alone**
- Where **biometry is unavailable**, the AL estimator may represent a **useful clinical tool** for identifying children at higher risk of axial growth-related complications of myopia.

References

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