Using Deep Learning to Automate Goldmann Applanation Tonometry Readings

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PURPOSE: To develop an objective and automated method for measuring intraocular pressure using deep learning and fixed-force Goldmann applanation tonometry (GAT) techniques.

DESIGN: Prospective cross-sectional study SUBJECTS: Patients from an academic glaucoma practice METHODS: Intraocular pressure (IOP) was estimated by analyzing videos recorded using a standard slit lamp microscope and fixed-force GAT. Video frames were labeled to identify the outline of the reference tonometer and the applanation mires. A deep learning model was trained to localize and segment the tonometer and mires. IOP values were calculated from the deep learning predicted tonometer and mire diameters using the Imbert-Fick formula. A separate test set was collected prospectively where standard and automated GAT were collected in random order by two independent masked observers to assess the deep learning model as well as inter-observer variability.

MAIN OUTCOME MEASURES: IOP measurements between standard and automated methods were compared.

RESULTS: 263 eyes from 135 subjects were included in the training and validation videos. For the test set, 50 eyes from 25 subjects were included. Each eye was measured by two observers, resulting in 100 videos. Within the test set, the mean difference between automated and standard GAT was -0.9 mmHg with 95% limits of agreement (LoA) of -5.4 to 3.6 mmHg. Mean difference between the two observers using standard GAT was 0.09 mmHg with LoA of -3.8 to 4.0. Mean difference between the two observers using automated GAT videos was -0.3 mmHg with LoA of -4.1 to 3.5 mmHg. The coefficients of repeatability for automated and standard GAT were 3.8 and 3.9 mmHg, respectively. The bias for even numbered measurements was reduced when using automated GAT.

CONCLUSION: Preliminary measurements using deep learning to automate GAT demonstrate comparable results to standard GAT. Automated GAT has the potential to significantly improve upon our current GAT measurement standards by reducing bias and improving repeatability. In addition, ocular pulse amplitudes could be observed using this technique.

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