Automated Computerized Eyelid Contour Measurement

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Purpose

Eyelid contour and margin position are key features of the oculofacial examination. These measurements are usually measured with a ruler or estimated by the examiner during the patient examination. Measurement of these key examination features obtained by computer analysis has the capability of providing more detailed and accurate descriptions of eyelid contour and margin position thus allowing for a more precise description of eyelid contour while eliminating examiner bias. Using methods described in computer vision literature[2,3], we have created a program to automatically generate eyelid contours and calculate the eyelid margin position from digital photographs. Here we demonstrate this automated method as a proof-of-concept by comparing the results obtained to those which were obtained by manual data input by an expert & non-expert investigator.

Methods

Ten RGB digital photographs of the eyelids, which were taken in a standard fashion with the patient in the frontal position, were analyzed for a total of 20 eyes. The images where input into the program which performed iris/pupil detection, determined upper eyelid margin position, and fit a quadratic function ($y = ax^2 + bx + c$) to the upper eyelid. The software detected its inability to calculate curvature on two images. These were then removed from our analysis.
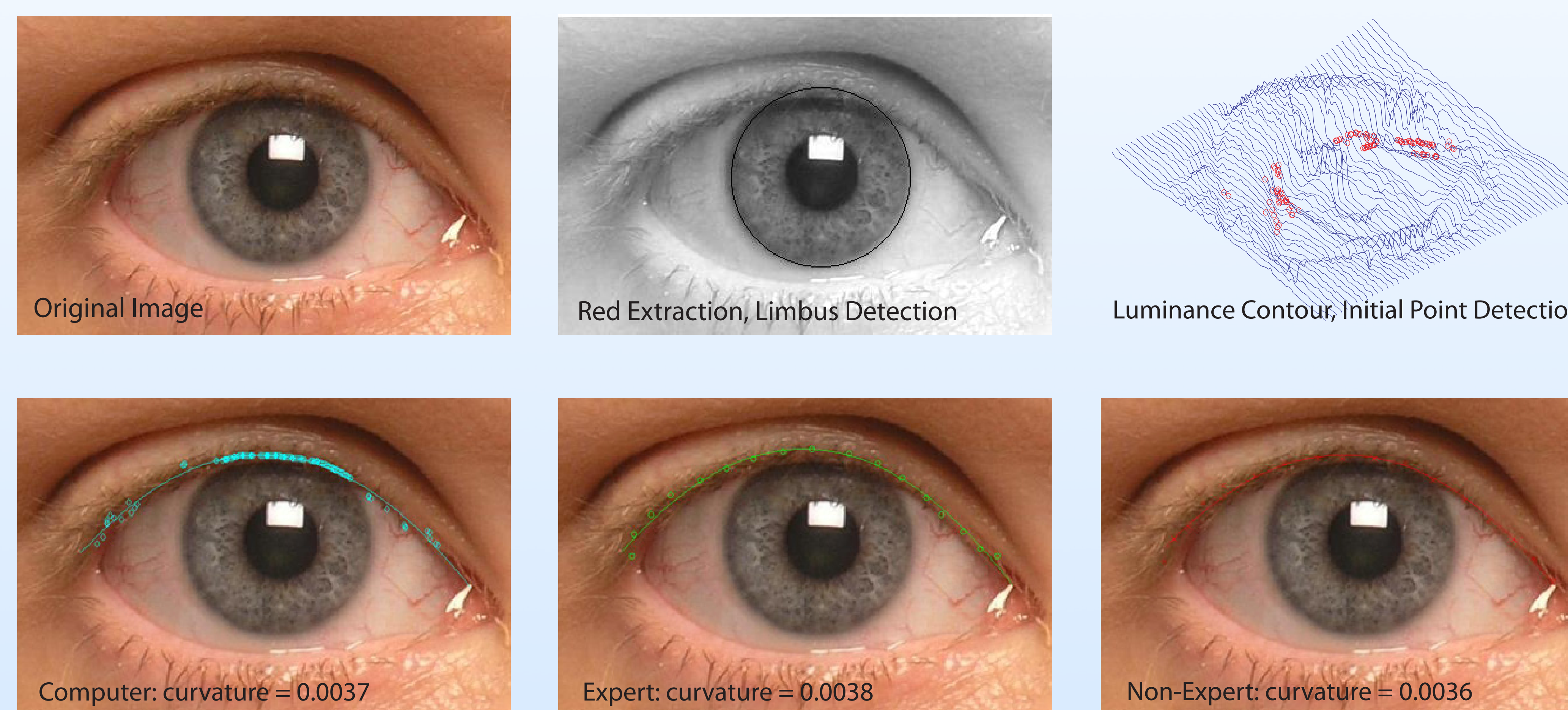
Separately, two investigators manually placed points along the upper eyelid margins of the same images and these points were fit to a quadratic function as well. The a coefficient was taken from each fit and was used as a measure of curvature.

The differences in curvature generated by the three methods (PC, expert, non-expert) were evaluated by examining the curvature deviation from the mean curvature of all three methods.
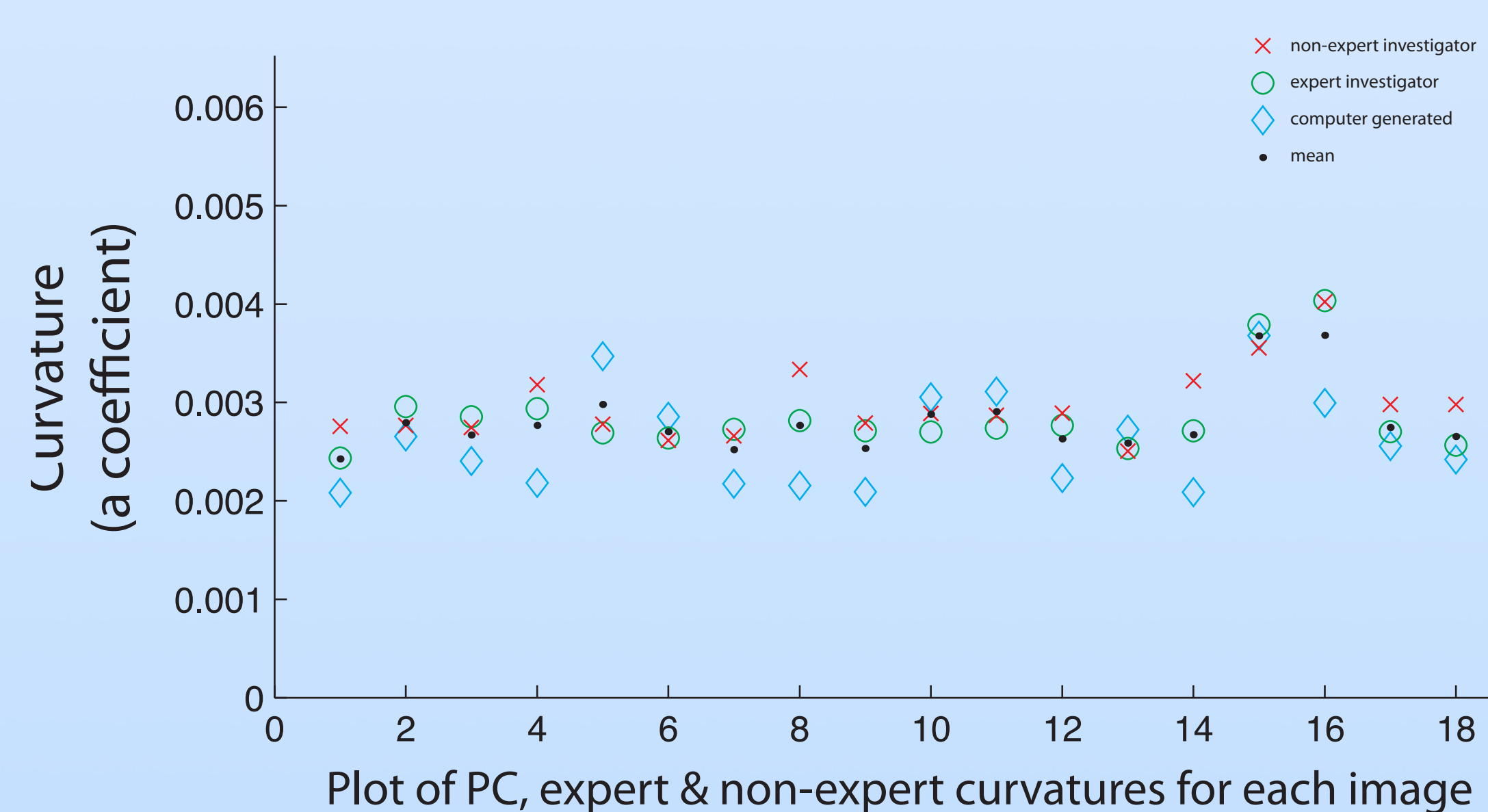
Lastly, we attempted to run our program against images acquired pre and post operatively on a blepharoplasty patient.

Results

### Example of Computer Generated Lid Contour

Original Image

Red Extraction, Limbus Detection

Luminance Contour, Initial Point Detection

Computer: curvature = 0.0037

Expert: curvature = 0.0038

Non-Expert: curvature = 0.0036

Comparison of Manual vs Computer Generated Contours

Deviation from mean	Mean	Std. Dev
Non-expert	0.00015	0.00023
Expert	0.00004	0.00016
Computer	-0.00020	0.00034

- Computer tended towards flatter curves (lower curvature) relative to expert

Pre & Post Operative Blepharoplasty Images Proof-of-Concept

Pre-Op

curvature = 0.0018

curvature = 0.0014

Post-Op

curvature = 0.0033

curvature = 0.0031
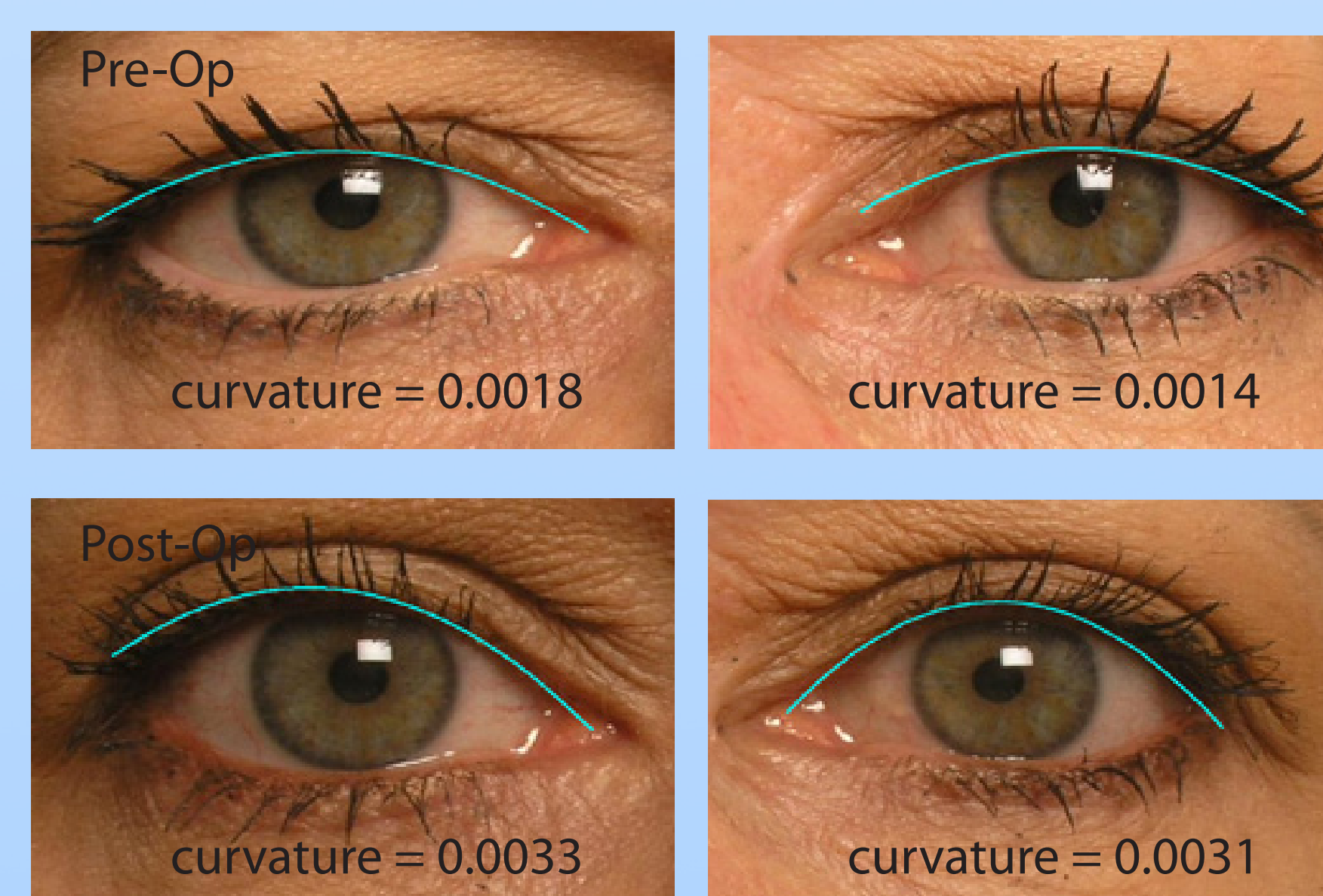
- Future applications of this method may include analyzing pre & post operative blepharoplasty patients

- For this patient, the software detected a pre-operative curvature asymmetry of 0.0004 and a post-operative asymmetry of 0.0002

Conclusions

- Computer generated quadratic curves were visually similar to those generated by an expert investigator.

- Prior literature defined upper lid contour using quadratic equations. In our study we note a visual discrepancy between a quadratic curve and true lid contour in all three methods.

- Our method has the ability to place a large number of points along the lid margin, which could allow for a more accurate mathematical description that is not practical using manual methods.

- A limitation of our study is that it utilizes a homogenous image database comprising of middle-aged Caucasian females. Future projects will have to be validated on a more diverse sample.

- This tool may provide the grounds for rapid, automated, and reproducible eyelid measurements from digital photographs.

- We hope to further refine this automated method of measurement so that it may be used as a tool for objectively defining lid contour in research and clinical settings.

References

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