Performance evaluation of ganglion cell analysis in normal and glaucoma population using multi-retinal layer segmentation

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PURPOSE

Optical coherence tomography (OCT) provides the ability to measure ganglion cell + inner plexiform layer thickness (GCIPL) and visualize the various tissues within the retina. GCIPL thickness is measured as the difference between the inner boundary of the retinal nerve fiber layer (RNFL) and the outer boundary of the inner plexiform layer (IPL). We have developed a multi-retinal layer segmentation algorithm (MLS) that segments the RNFL and IPL as well as other layers. The purpose of this study is to evaluate the performance of the GCIPL analysis using MLS algorithm.

METHODS

- Subjects with no retinal disease and with glaucoma were recruited from 2 sites and scanned with the 200x200 and 512x218 macular cube scans over 6x6 mm using the CIRRUS™ HD-OCT 5000 (ZEISS, Dublin, CA).
- Accuracy of MLS was compared against RNFL and IPL segmentations hand-drawn by a grader trained in segmenting OCT volumetric images (gold standard).
- The grader drew RNFL and IPL boundaries over three specified B-scans (at 2.1mm, 3 mm, 3.89 mm) per OCT volume (512x218 macular cube scans).
- Bland Altman and regression plots are reported on a total of 132 B-scans. The repeatability, coefficient of variance (COV) and receiver operating characteristic (ROC) curve for each subfield of the EDTRS grid centered on the fovea is reported from 49 normal subjects (282 cube scans) and 49 glaucoma subjects (244 cube scans).

CONCLUSIONS

Our proposed segmentation algorithm achieves high accuracy, repeatability and reproducibility for GCIPL thickness analysis. It is therefore a promising tool to detect glaucoma and monitor its progression using OCT imaging.

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RESULTS

In the Bland Altman and regression plots (Figure 1), the overall mean difference between MLS and manual segmentation for RNFL and IPL was found to be less than +/- 3 µm. R values show a very high correlation between gold standard and MLS. The 95% limits (+/- 1.96 times standard deviation) of the difference between gold standard and MLS calculated for RNFL and IPL are also reported. The area under the curve (AUC) was calculated in all subfields (Figure 2). The minimum AUC was 0.94 (subfield 3) and the maximum AUC was 0.99 (subfield 6). The repeatability of the GCIPL layer thicknesses of normal and glaucoma cases were calculated separately for all 6 subfields (Table 1). The COV for normal cases was less than 2.4%. The largest COV for glaucoma cases was 6% (subfield 4).

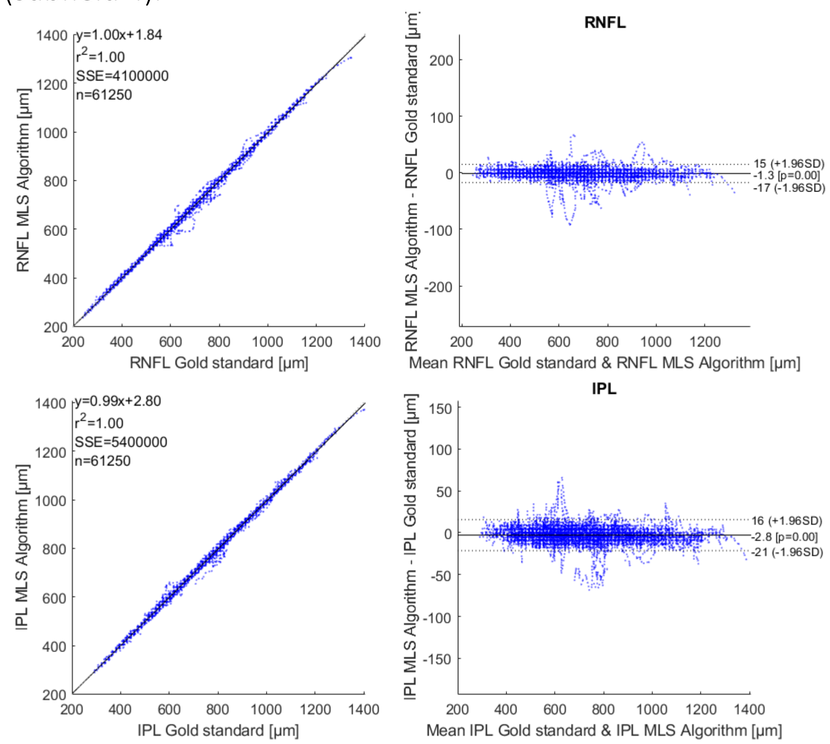

Figure 1. Regression and Bland Altman plots for MLS and manual segmentation for RNFL and IPL

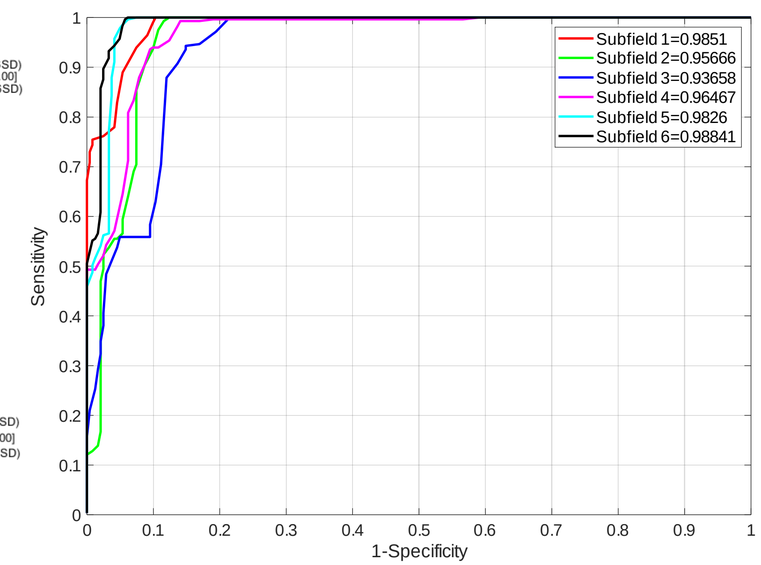

Figure 2. ROC curve for each subfield

	Normal			Glaucoma		
Subfield	Mean [µm]	Repeatability SD [µm]	Coefficient of Variance [%]	Mean [µm]	Repeatability SD [µm]	Coefficient of Variance [%]
1	82.331	0.73	0.9%	55.604	2.10	3.8%
2	85.136	0.71	0.8%	55.605	1.98	3.2%
3	86.439	0.60	0.7%	62.83	1.64	2.5%
4	85.799	2.03	2.4%	66.559	3.68	6.0%
5	83.755	0.77	0.9%	60.968	2.37	4.4%
6	83.531	0.68	0.8%	54.086	2.94	5.9%

Table 1. The mean thickness, repeatability and COV for each subfield for normal and glaucoma cases

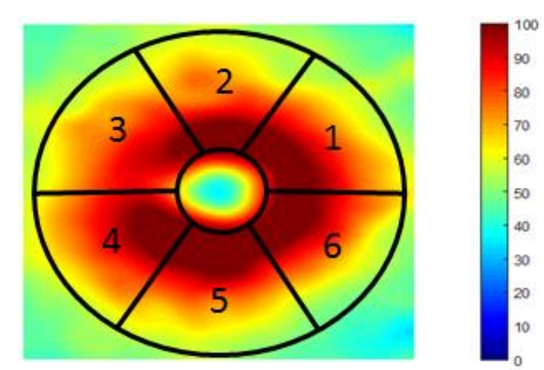

Figure 3. Subfields of the EDTRS grid