Robust macula thickness analysis using low-cost OCT

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Poster # 3312 – F0121

PURPOSE

Remote OCT applications require cost-effective acquisition devices. This challenging constraint often leads to technology choices that provide inferior image quality compared to state-of-the-art clinical devices, and thereby result in unreliable image analysis. The purpose of this work is to demonstrate a strategy for robust macula thickness analysis using low-cost OCT that can navigate data quality limitations and improve correlation of thickness values compared with benchmark clinical systems.

METHOD

- Our method relies on acquiring multiple OCT scans of the same region and intelligently combining the macula thickness maps.
- A thickness map (TM) and segmentation confidence map (SCM) are generated for each OCT volume. All TMs are registered to the TM (reference) with highest confidence derived from the SCM.
- The registration transformation are used to register and combine the TMs into a single map based on the local quality of individual SCMs.
- To evaluate this method, we acquired OCT scans over an area of 5.78mm x 5.78mm, repeated 3 times on a low-cost OCT.
- 38 patients with retina pathology were enrolled in an IRB-approved study. The final TM was compared to one acquired using a CIRRUS™ HD-OCT 5000 (ZEISS, Dublin, CA). Thickness values were compared over an ETDRS grid.

RESULTS

Figure 1 below shows examples of thickness maps acquired using the low-cost OCT (before and after combining) and using CIRRUS HD-OCT 5000. Bland-Altman analysis was performed to compare the results of single acquisition and triple acquisition of the low-cost system with a single acquisition of CIRRUS HD-OCT 5000. The results are summarized in Table 1 below. The combined acquisition provides slightly higher mean difference while improving the correlation with the clinical system in the outer ring.

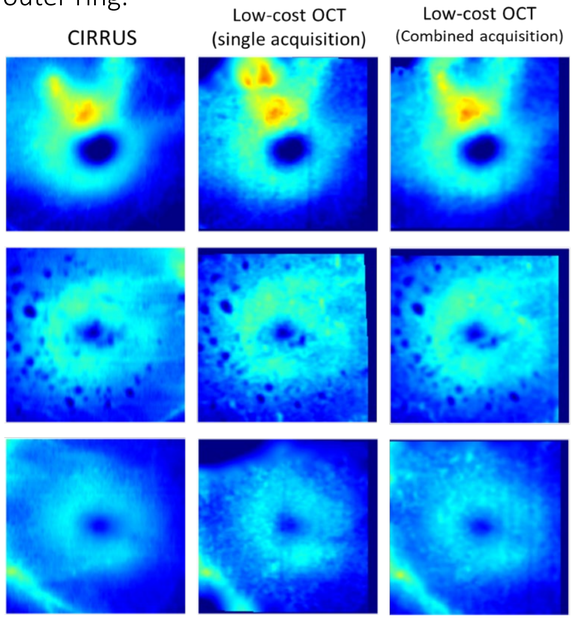

Figure 1. Macula thickness maps acquired using CIRRUS HD-OCT 5000 and low-cost OCT after registration to CIRRUS thickness map

ETDRS grid subfields	*Low-cost OCT (Single acquisition) vs CIRRUS 5000 HD-OCT*	*Low-cost OCT (Combined acquisition) vs CIRRUS 5000 HD-OCT*
Central	Mean difference (µm): 6.8 95% limits (µm): (-18, 32) Correlation (r^2): 0.80	Mean difference (µm): 6.5 95% limits (µm): (-13.0, 26.0) Correlation (r^2): 0.88
Inner Inferior	Mean difference (µm): 5.4 95% limits (µm): (-2.4, 13.0) Correlation (r^2): 0.96	Mean difference (µm): 5.7 95% limits (µm): (-2.9, 14.0) Correlation (r^2): 0.95
Inner Nasal	Mean difference (µm): 3.8 95% limits (µm): (-5.6, 13.0) Correlation (r^2): 0.95	Mean difference (µm): 5.3 95% limits (µm): (-2.2, 13.0) Correlation (r^2): 0.96
Inner Superior	Mean difference (µm): 5.0 95% limits (µm): (-3.6, 14.0) Correlation (r^2): 0.98	Mean difference (µm): 5.9 95% limits (µm): (-3.0, 15.0) Correlation (r^2): 0.97
Inner Temporal	Mean difference (µm): 4.8 95% limits (µm): (-5.3, 15.0) Correlation (r^2): 0.94	Mean difference (µm): 5.9 95% limits (µm): (-3.4, 15.0) Correlation (r^2): 0.95
Outer Inferior	Mean difference (µm): 3.3 95% limits (µm): (-18.0, 24.0) Correlation (r^2): 0.81	Mean difference (µm): 5.0 95% limits (µm): (-8.8, 19.0) Correlation (r^2): 0.91
Outer Nasal	Mean difference (µm): 2.3 95% limits (µm): (-10.0, 15.0) Correlation (r^2): 0.89	Mean difference (µm): 4.9 95% limits (µm): (-4.2, 14.0) Correlation (r^2): 0.94
Outer Superior	Mean difference (µm): 5.6 95% limits (µm): (-11.0, 22.0) Correlation (r^2): 0.92	Mean difference (µm): 6.7 95% limits (µm): (-4.1, 18.0) Correlation (r^2): 0.96
Outer Temporal	Mean difference (µm): 6.3 95% limits (µm): (-12.0, 24.0) Correlation (r^2): 0.93	Mean difference (µm): 6.8 95% limits (µm): (-7.2, 21.0) Correlation (r^2): 0.95

Table 1: Summary of Bland-Altman analysis of thickness values in an ETDRS grid

CONCLUSION

Our analysis suggests that combining macula thickness maps from multiple acquisitions provides an overall improved correlation between the low-cost system and clinical system, and thereby improves the diagnostic utility of the low-cost OCT instrument.

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Disclosures: AF (E), HB (E), CL (E), SAB (E): Carl Zeiss Meditec, Inc.