Repeatability Using Automatic Tracing with Canon OCT- HS100 and Zeiss Cirrus HD-OCT 5000

Rune Brautaset *, Ulrika Birkeldh, Petra Frehr Alstig, Petra Wikén, Maria Nilsson

Unit of Optometry, Department of Clinical Neuroscience, St. Erik Eye Hospital, Karolinska Institutet, Stockholm, Sweden

* rune.brautaset@ki.se

Abstract

Background
Optical coherence tomography (OCT), can be used in clinical practice to provide high resolution cross-sectional images of the retina, optic disc and macula structure. These measurements can be useful for early detection, diagnosis, monitoring and treatment guidance for retinal diseases. Therefore, repeatability of measurements in OCT is of great importance.

Methods
Macula and optic disc parameters from the right eye of 30 healthy subjects were obtained twice with the Canon OCT-HS100 and Zeiss Cirrus HD-OCT 5000. Repeatability was evaluated by use of the coefficient of repeatability (CR) and the coefficient of repeatability as a percentage of the mean (CR%), and the obtained measurements were compared between the instruments.

Results
CR% of optic disc parameters ranged between 0.90 and 22.22% and 0.00 and 16.00% with the Canon and Zeiss OCT respectively. For macular parameters CR% ranged between 0.62 and 2.81% and 0.99 and 1.81% with the Canon and Zeiss OCT respectively. No statistical difference could be found when comparing the CR of all macular and disc measurements between the instruments. Compared to our previously published data repeatability has significantly improved with the inclusion of automatic tracking systems with both the Canon and Zeiss OCT.

Conclusion
Automatic tracking function improves repeatability in both Canon OCT-HS100 and Zeiss Cirrus HD-OCT 5000. However, measurements generated by the two instruments are still not interchangeable.
Introduction

Optical coherence tomography (OCT), is used in clinical practice to provide high resolution cross-sectional images of the retina, optic disc and macula. Each of the retinas’ distinctive layers can be seen, allowing the clinician to map and measure their thickness. These measurements can be useful for early detection, diagnosis, monitoring and treatment guidance for retinal diseases, such as age related macular degeneration [1,2], glaucoma [3–5] and multiple sclerosis [6–8].

OCT measurement is a non-invasive, non-contact imaging system and provides instant imaging. In comparison to, e.g., ultrasound it gives higher image resolution [9]. The measurements do not require pupil dilation in order to produce high image quality [10–12].

The test time is rather short, but may require the patient’s cooperation in terms of not blinking and maintaining a steady fixation. To improve measurements and simplify the procedure for both patients and operators, some suppliers have incorporated automatic retinal tracking system.

Langnegger et al. [13] (using the Heidelberg Spectralis SD-OCT) showed that the repeatability was good in both normal and glaucomatous eyes and could be significantly improved by using an automatic tracing system. These findings suggested that automatic tracking was capable of significantly improving the repeatability of retinal nerve fiber (RNFL) thickness measurements due to automatic re-scanning when fixation errors and blinks occurred [13]. In general the repeatability of SD-OCT measurements have been found to be high [14], however, differences between instruments can be caused by differences in the algorithms used to detect retinal structural layers [15,16]. Differences between instruments are therefore likely to occur when comparing segmented images. Retinal diseases, such as epiretinal membranes, will also affect the ability to detect structures and consequently also repeatability [17,18].

In a previously published paper we [19] evaluated and compared the repeatability of disc and macula OCT measurements without the use of automatic eye tracking with the Canon OCT-HS100 and Zeiss Cirrus-OCT 4000. In newer models of both instruments (software upgrade in the Canon and version 5000 of the Zeiss OCT) automatic tracing systems are available. During scanning, both OCTs automatically track the retina which makes the scanning procedure immediately recover in case of eye movements or blinking, i.e., an additional scan is automatically performed to correct the error. Since this function prevents re-taking scans due to eye movement it saves time in a clinical setting. With this feature, OCT measurements can be less operator dependent. It also makes it easier to obtain scans from patients who have difficulties maintaining a steady fixation (e.g., children or patients with impaired fixation ability due to maculopaties) [20]. Due to the ability to recollect the exact same location in the retinal tissue as in previous examination, it enhances comparison and monitoring progression of pathologies in the retina.

The purpose of the study was to evaluate the repeatability of OCT measurements in healthy eyes obtained with the Canon OCT-HS100 (version 4.00) and the Zeiss Cirrus HD-OCT 5000 (version 8.0) with the use of their incorporated automatic tracking systems.

Methods

Thirty consecutive subjects, without ocular pathologies, in whom well-segmented OCT images could be obtained, were included in the study. The mean age was 35.2 years (range 22–66) and the female/male ratio was 24/6. Scans with the Cirrus HD-OCT 5000 (version 8.0) were obtained in the Open Clinic at the Unit of Optometry, St. Erik Eye Hospital, Stockholm, Sweden and with the Canon OCT–HS100 (version 4.00) at the nearby Neurology department at the Karolinska Hospital. Only the right eye of each subject was included. The measurements...
were performed without the use of mydriatic drops [10–12]. The study was approved by the regional ethics committee in Stockholm (Regionala Etikprövningsnämnden i Stockholm) and performed in accordance with the ethical standards stated in the Declaration of Helsinki. Each subject signed an informed consent before the enrolment in the study.

Exclusion criteria were poor OCT image quality (signal strength \( \leq 7 \)), presence of media opacities, epiretinal membrane or vitreomacular traction, and a history of ocular trauma.

The Canon OCT-HS100 has an A-scan velocity of 70,000 scans/sec with a claimed axial resolution of 3 μm and a scanning depth of 2 mm. The scanning width is between 2 and 10 mm and the wavelength used is 835 nm. With the Canon OCT-HS100 a Disc 3D and a Macula 3D scans were obtained. The customized 3D scan for evaluation of the optic nerve head (Disc 3D) is acquired over a 6X6 mm area by 256 B-scans each composed of 512 A-scans. The macular cube measurement (Macula 3D) is built up from 128 B-scans each composed of 1024 A-scans within a 10X10 mm area.

The Cirrus HD-OCT 5000 has an A-scan velocity of 27,000 scans/sec with a 5 μm axial resolution and a scanning depth of 2 mm. The instrument uses light of 840 nm wavelength and scans an area of 6X6 mm for both macula and disc scans. With the Cirrus HD-OCT the Optic Disc and Macular Cubes were obtained. The Optic Disc Cube acquires 200 B-scans, each composed of 200 A-scans. The Macular Cube acquires 128 B-scans each composed of 512 A-scans. With both instruments all scans obtained were reviewed to assert that segmentation was correct before analysis was done. All scans were obtained twice with the subjects being re-seated in front of the instrument before the second scan.

Only equivalent parameters obtained by both instruments were used for analysis. For optic disc measurements disc area, rim area, cup volume, vertical cup/disc (C/D) ratio, retinal nerve fibre layer (RNFL) average thickness and RNFL thickness in the four quadrants of the optic nerve head (i.e., according to ISNT–inferior, superior, nasal and temporal) were used. For macular measurements the nine subfields corresponding to the Early Treatment of Diabetic Retinopathy Study (EDTRS) [21] areas were used. ETDRS areas are defined by three concentric rings centred into the fovea with diameters of 1, 3 and 6 mm lines.

The main objective was to evaluate macula and optic disc measurement repeatability using the automatic tracing function in the Canon OCT-HS100 and the Zeiss Cirrus HD-OCT 5000 and to evaluate whether the function improved the repeatability in comparison to the study of Brautaset et al. [19].

**Results**

The coefficient of repeatability (CR) was calculated according to the methods outlined by Bland and Altman [22] for each of the optic disc and macular thickness parameters (1.96 x square root of the within-subject variance from repeated measurements). Also the coefficient of repeatability as a percentage of the mean (CR%) was calculated (CR% = (CR/mean)×100).

The squared Pearson correlation coefficient (\( R^2 \)) was also calculated for each of the measurements and the difference between the first and the second measurement statistically evaluated to see if it differed from zero. For comparison between the two instruments statistical comparison of the CR values were done, alongside squared Pearson correlation (\( R^2 \)). In all thirty subjects scans with signal strength \( \geq 7 \) were obtained. For analysis of vertical C/D ratio one subject was excluded since one instrument estimated the C/D ratio to be zero which is physiologically impossible.

Average results for all the optic disc and macular thickness parameters can be seen in Tables 1 and 2 respectively together with statistical analysis of the difference between the first and second measurement with each instrument (one-sample t test or Wilcoxon rank-sum test.
dependent on distribution). In Table 3 the mean difference (Canon-Zeiss) for each disc and macular parameter can be seen together with statistical evaluation of between instrument comparisons (One-way analysis of variance with post-hoc test). For all statistical analysis statistical significance threshold was set to $P < 0.05$.

For comparison of the two instruments, paired t-test was used to evaluate differences in CR values; no statistical difference could be found ($t = 0.49; p = 0.63$).

**Discussion**

This study provides data of the test-retest repeatability using automatic tracking with the Canon OCT-HS100 and Zeiss Cirrus HD-OCT 5000. In general, the measured optic disc and macular values were found to be repeatable with CR% values in optic disc parameters ranging between 0.90 and 22.22%, and between 0.00 and 16.00% with the Canon and Zeiss respectively.

---

**Table 1. Repeatability of optic disc parameters.**

| Optic disc parameters (within instruments) | Canon OCT-HS100 | Zeiss Cirrus HD-OCT |
|--------------------------------------------|----------------|--------------------|
| Mean CR CR% R² p                           | Mean CR CR% R² p |
| Disc area (mm²)                            | 2.08 ±0.41      | 0.21 10.10 0.92 0.61 | 1.87 ±0.35      | 0.10 5.34 0.96 0.71 |
| Rim area (mm²)                             | 1.58 ±0.37      | 0.20 12.66 0.97 0.55 | 1.41 ±0.24      | 0.08 5.67 0.97 0.97 |
| Cup volume (mm³)                           | 0.09 ±0.12      | 0.02 22.22 0.98 0.63 | 0.13 ±0.12      | 0.02 16.00 0.99 0.71 |
| C/D vertical ratio                         | 0.48 ±0.14      | 0.05 10.41 0.97 0.96 | 0.47 ±0.12      | 0.04 8.51 0.96 0.45 |
| RNFL average (µm)                          | 99.16 ±8.57     | 5.46 5.11 0.93 0.15 | 93.96 ±8.95     | 3.39 3.61 0.96 0.21 |
| RNFL Inferior (µm)                         | 127.80 ±36.47   | 1.15 0.90 0.92 0.71 | 122.86 ±34.41   | 1.09 0.89 0.96 0.61 |
| RNFL Superior (µm)                         | 118.36 ±31.43   | 2.27 1.92 0.76 0.16 | 112.57 ±30.29   | 0.89 0.79 0.94 0.68 |
| RNFL Nasal (µm)                            | 80.52 ±18.94    | 2.09 2.60 0.89 0.15 | 72.23 ±17.33    | 0.00 0.98 0.99 |
| RFNL Temporal (µm)                         | 69.60 ±16.03    | 1.50 2.16 0.91 0.35 | 65.11 ±16.24    | 0.89 1.37 0.97 0.53 |

$(C/D = cup/disc; CR = coefficient of repeatability; CR% = coefficient of repeatability as a percentage of mean; RNFL = Retinal nerve fiber layer. $t = one-sample t test / w = Wilcoxon rank-sum test)$

doi:10.1371/journal.pone.0149138.t001

**Table 2. Repeatability of macular parameters.**

| Macular parameters (within instruments) | Canon OCT-HS100 | Zeiss Cirrus HD-OCT |
|----------------------------------------|----------------|--------------------|
| Mean CR CR% R² p                       | Mean CR CR% R² p |
| Centre                                 | 276.22 ±15.69  | 5.04 1.82 0.97 0.95 | 259.34 ±15.97  | 2.57 0.99 0.99 0.55 |
| Inner superior                         | 351.08 ±12.07  | 2.82 0.80 0.98 0.99 | 324.82 ±11.48  | 5.25 1.62 0.95 0.36 |
| Inner nasal                            | 352.02 ±14.13  | 3.11 0.88 0.99 0.07 | 327.27 ±13.72  | 4.28 1.31 0.97 0.36 |
| Inner inferior                         | 347.33 ±10.99  | 4.46 1.28 0.95 0.71 | 322.38 ±11.99  | 4.05 1.26 0.97 0.58 |
| Inner temporal                         | 335.34 ±10.82  | 2.09 0.62 0.99 0.90 | 311.41 ±10.57  | 4.20 1.35 0.96 0.15 |
| Outer superior                         | 305.21 ±12.17  | 8.58 2.81 0.89 0.16 | 277.65 ±12.42  | 6.65 1.67 0.96 0.38 |
| Outer nasal                            | 317.66 ±14.57  | 2.98 0.94 0.99 0.29 | 295.48 ±14.24  | 3.57 1.21 0.98 0.44 |
| Outer inferior                         | 290.74 ±12.22  | 4.80 1.65 0.97 0.35 | 267.27 ±14.21  | 3.73 1.40 0.98 0.26 |
| Outer temporal                         | 287.54 ±10.17  | 4.00 1.39 0.96 0.69 | 258.96 ±9.55   | 4.70 1.81 0.93 0.50 |

Repeatability of macular parameters obtained with the Canon OCT-HS100 and Zeiss Cirrus HD-OCT 5000. $(C/D = cup/disc; CR = coefficient of repeatability; CR% = coefficient of repeatability as a percentage of mean. t = one-sample t test. w = Wilcoxon rank-sum test)$

doi:10.1371/journal.pone.0149138.t002
Slight differences in repeatability between the instruments can be due to the difference in resolution between the instruments. Lower resolution, as with the Zeiss, may make it easier to replicate the segmentation. However, differences between instruments can also be caused by differences in the algorithms used to define retinal structural layers independent of resolution [15,16]. When excluding cup volume from the analysis, CR% values of the optic disc, range from 0.90 to 12.66% and 0.00–8.51% with the Canon and Zeiss respectively, which is in line with prior studies [19,23–27]. Measurements in the macular region provided good repeatability, better than in the optic disc. This result is probably due to anatomical features, for example the absence of large blood vessels in the macula [14]. The CR% for macular parameters ranged between 0.62 and 2.81%, and 0.99 and 1.81% with the Canon and Zeiss respectively.

The least repeatable measurements were obtained for the cup volume in both instruments. Measuring the cup volume and C/D-ratio has shown to be difficult. This is in agreement with other studies [19,22,26]. In comparison to the study of Brautaset et al. [19] the CR% in macula has increased with the automatic tracking.

In general, all measurements obtained with the Canon OCT are greater/thicker in both the optic disc and macular region with exception of C/D-vertical ratio and cup-volume (Table 3). This can most likely be explained by different scanning circle diameter, where the Canon device uses a slightly smaller scanning circle [19]. In spite of this, the correlation between the two devices is good, but because of the difference in thickness estimation, they are not interchangeable.

### Table 3. Between instrument comparison.

|                        | Between instrument comparison |
|------------------------|-------------------------------|
|                        | Optic disc                    | Macula                        |
|                        | Mean difference (p-value)     |                                |
|                        | R² (p-value)                  |                                |
| Disc area (mm²)        | 0.22 (p>0.05)                 | 16.87 (p<0.05)                |
| Rim area (mm²)         | 0.17 (p>0.05)                 | 0.43 (p<0.05)                 |
| Cup volume (mm³)       | -0.03 (p>0.05)                | 26.25 (p<0.05)                |
| C/D vertical ratio     | -0.03 (p>0.05)                | 24.74 (p<0.05)                |
| RNFL average (μm)      | 5.20 (p>0.05)                 | 24.95 (p<0.05)                |
| RNFL Inferior (μm)     | 5.36 (p>0.05)                 | 23.93 (p<0.05)                |
| RNFL Superior (μm)     | 5.43 (p>0.05)                 | 27.55 (p<0.05)                |
| RNFL Nasal (μm)        | 8.02 (p>0.05)                 | 22.18 (p<0.05)                |
| RFNL Temporal (μm)     | 4.00 (p>0.05)                 | 23.46 (p<0.05)                |

Between instrument comparison of the Canon OCT-HS100 and Zeiss Cirrus HD-OCT 5000, mean difference (Canon-Zeiss) and correlation coefficient (R²). (C/D = cup/disc; RNFL = Retinal nerve fibre layer. Positive values denote greater/thicker measurement obtained with the Canon OCT-HS100, and negative values lower/thinner values.)

doi:10.1371/journal.pone.0149138.t003
Repeatability is of great importance in a clinical setting when monitoring the progression of, for example, glaucoma. Viewing this result, it seems as if the automatic tracking function makes obtaining measurements less operator dependent.

On the other hand, in the study of Langenegger et al. [13] using Spectralis SD-OCT with a similar eye tracking system the repeatability on glaucoma eyes was significantly higher. This indicates that eye tracking improves repeatability in pathological eyes. If this is the case using Cirrus and Canon needs to be evaluated.

The aim of this study was also to evaluate whether automatic tracking function in Canon and Zeiss OCT has improved the repeatability. In order to analyse this, the CR values from this study were compared with the CR values of the study performed by Brautaset et al. [19]. Statistically analysis found the CR values to significantly lower with the automatic tracing for both the Canon (t = 3.348; p = 0.0038) and Zeiss (t = 4.80; p = 0.0008) OCT.

In clinical practice, a reduction of 4.3 μm of RNFL thickness is considered a clinically significant glaucomatous structural change [28]. The variation of CR in the present study ranges with the Canon from 0.90 to 2.60 μm regarding ISNT-measurements. In Zeiss, the CR ranged between 0.00 and 1.37 μm. This implicates that the instrument variability within ISNT are accurate enough regarding clinical use.

In conclusion the automatic tracking function improves repeatability in both Canon OCT-HS100 and Zeiss Cirrus HD-OCT 5000. However, due to the difference in thickness estimation the measurements made by the two instruments are still not interchangeable.

Supporting Information

S1 File. Raw data first measurement Canon and Zeiss OCT. (PDF)

S2 File. Raw data second measurement Canon and Zeiss OCT. (PDF)

Author Contributions

Conceived and designed the experiments: RB UB MN. Performed the experiments: UB PFA PW. Analyzed the data: RB UB PFA PW MN. Contributed reagents/materials/analysis tools: RB UB PFA PW MN. Wrote the paper: RB UB PFA PW MN.

References

1. de Sisternes L, Simon N, Tibshirani R, Leng T, Rubin DL. Quantitative SD-OCT imaging biomarkers as indicators of age-related macular degeneration progression. Invest Ophthalmol Vis Sci. 2014; 55 (11):7093–103. doi: 10.1167/iovs.14-14918 PMID: 25301882

2. Chen Y, Vuong LN, Liu J, Ho J, Srinivasan VJ, Gorczynska I, et al. Three-dimensional ultrahigh resolution optical coherence tomography imaging of age-related macular degeneration. Opt Express 2009; 17(5):4046–60. PMID: 19259245

3. Wong E, Yoshioka N, Kalloniatis M, Zangerl B. Cirrus HD-OCT Short-Term Repeatability of Clinical Retinal Nerve Fiber Layer Measurements. Optometry and Vision Science 2015; 92(1):83–88. doi: 10.1097/OPX.0000000000000452 PMID: 25479451

4. Simavli H, Que CJ, Akduman M, Rizzo JL, Tsikata E, de Boer JF. Diagnostic Capability of Peripapillary Retinal Thickness in Glaucoma Using 3D Volume Scans. Am J Ophthalmol. 2015; 159(3):545–556. doi: 10.1016/j.ajo.2014.12.004 PMID: 25498354

5. Schulze A, Lamparter J, Pfeiffer N, Berisha F, Schmidtmann I, Hoffmann EM. Diagnostic ability of retinal ganglion cell complex, retinal nerve fiber layer, and optic nerve head measurements by Fourier-domain optical coherence tomography. Graefes Arch Clin Exp Ophthalmol 2011; 249(7):1039–45. doi: 10.1007/s00417-010-1585-5 PMID: 21240522
6. Serbecic N, Aboul-Enein F, Beutelspacher SC, Khan A, Vass C, Kristoferitsch W, et al. High-Resolution Spectral Domain-Optical Coherence Tomography in Multiple Sclerosis, Part II—the Total Macular Volume. The First Follow-Up Study over 2 Years. Front Neurol. 2014; 5:20 doi:10.3389/fneur.2014.00020 PMID: 24605107

7. Huang J, Dai H, Zhang H, Wang X, Chen T. Clinical investigation of optic coherence tomography in evaluating the impairment of optic nerve secondary to multiple sclerosis. Zhonghua Yan Ke Za Zhi 2014; 50(12):900–5. PMID: 25619181

8. Talman LS, Bisker ER, Sackel DJ, Long DA Jr, Galetta KM, Ratchford JN, et al. Longitudinal study of vision and retinal nerve fiber layer thickness in multiple sclerosis. Author information. Ann Neurol. 2010; 67(6):749–60. doi: 10.1002/ana.22005 PMID: 20517936

9. Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W, et al. Optical coherence tomography. Science 1991; 254:1178–1181. PMID: 1957169

10. Massa GC, Vidotti VG, Cremasco F, Lupinacci AP, Costa VP. Influence of pupil dilation on retinal nerve fibre layer measurements with spectral domain OCT. Eye (Lond) 2010; 24:1498–502.

11. Savini G, Carbonelli M, Parisi V, Barboni P. Effect of pupil dilatation on retinal nerve fibre layer thickness measurements and their repeatability with Cirrus HD-OCT. Eye (Lond) 2010; 24:1503–6.

12. Langenegger SJ, Funk J, Töteberg-Harms M. Reproducibility of retinal nerve fiber layer thickness measurements using the eye tracker and the retest function of Spectralis SD-OCT in glaucomatous and healthy control eyes. Invest Ophthalmol Vis Sci. 2011; 52(6):3338–44. doi: 10.1167/iovs.10-6611 PMID: 21330656

13. Pierro L, Gagliardi M, Iuliano L, Ambrosi A, Bandello F. Retinal nerve fiber layer thickness reproducibility using seven different OCT instruments. Invest Ophthalmol Vis Sci. 2012; 53(9):5912–20. doi: 10.1177/1011193X12467035 PMID: 22871835

14. Liu X, Shen M, Huang S, et al. Repeatability and reproducibility of eight macular intra-retinal layer thicknesses determined by an automated segmentation algorithm using two SD-OCT instruments. PLoS One. 2014; 9: e87996. doi: 10.1371/journal.pone.0087996 PMID: 24505345

15. de Sisternes L, Hu J, Rubin DL, Marmor MF. Localization of damage in progressive hydroxychloroquine retinopathy on and off the drug: inner versus outer retina, parafovea versus peripheral fovea. Invest Ophthalmol Vis Sci. 2015; 56(1):3415–26. doi: 10.1167/iovs.14-16345 PMID: 26024126

16. Pinilla I, Garcia-Martin E, Fernandez-Larripa S, Fuentes-Broto L, Sanchez-Cano AI, Abeica E. Reproducibility and repeatability of Cirrus and Spectralis Fourier-domain optical coherence tomography of healthy and epiretinal membrane eyes. Retina. 2013; 33:1448–1455. doi: 10.1097/IAE.0b013e3182807683 PMID: 23538575

17. Lee HJ, Kim MS, Jo YJ, Kim JY. Thickness of the Macula, Retinal Nerve Fiber Layer, and Ganglion Cell Layer in the Epiretinal Membrane: The Reproducibility Study of Optical Coherence Tomography. Invest Ophthalmol Vis Sci. 2015; 56(8):4554–60. doi: 10.1167/iovs.15-16949 PMID: 26200495

18. Brautaset R, Birkeildh U, Rosén R, Ramsay MW, Nilsson M. Reproducibility of disc and macula optical coherence tomography using the Canon OCT-HS100 as compared with the Zeiss Cirrus HD-OCT. Eur J Ophthalmol 2014; 24(5):722–7. doi: 10.5301/ejo.5000437 PMID: 24519507

19. Bentaleb-Machkour Z, Jouffroy E, Rabilloud M, Grange JD, Kedjikian L. Comparison of central macular thickness measured by three OCT models and study of interoperator variability. Scientific World Journal 2012; (2012), Article ID 842795.

20. Early Treatment Diabetic Retinopathy Study Research Group. Photocoagulation for diabetic macular edema, Early Treatment Diabetic Retinopathy Study Report No 1. Arch Ophthalmol 1985; 103:1796–1806.

21. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods for clinical measurement. Lancet 1986; 1:307–10. PMID: 2868172

22. Sato S, Hirooka K, Baba T, Shiraga F. Comparison of optic nerve head parameters using Heidelberg Retina Tomograph 3 and spectral-domain optical coherence tomography. Clin Experiment Ophthalmol 2012; 40(7):721–726. doi: 10.1111/j.1442-9071.2012.02782.x PMID: 22394383

23. Altemir I, Pueyo V, Elia N, Polo V, Larrosa JM, Oros D. Reproducibility of optical coherence tomography measurements in children. Am J Ophthalmol 2013; 155(1):171–176. doi: 10.1016/j.ajo.2012.06.012 PMID: 22967864
25. Parravano M, Oddone F, Boccassini B, Menchini F, Chiaravalloti A, Schiavone M, et al. Reproducibility of macular thickness measurements using Cirrus SD-OCT in neovascular Age-Related Macular Degeneration. Invest Ophtalmol. Vis. Sci. 2010; 51(9):4788–91.

26. Menke MN, Knecht P, Sturm V, Dabov S, Funk J. Reproducibility of Nerve Fiber Layer Thickness Measurements Using 3D Fourier-Domain OCT Invest. Ophthalmol. Vis. Sci. 2008; 49(12):5386–5391. doi: 10.1167/iosvs.07-1435 PMID: 18676630

27. Matlach J, Wagner M, Malzahn U, Göbel W. Repeatability of Peripapillary Retinal Nerve Fiber Layer and Inner Retinal Thickness Among Two Spectral Domain Optical Coherence Tomography device. Invest. Ophtalmol. Vis. Sci. 2014; 55(10):6536–6546.

28. Lee EJ, Kim TW, Park KH. Ability of stratus OCT to detect progressive retinal nerve layer atrophy in glaucoma. Invest Ophtalmol Vis Sci. 2009; 50:662–668