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Objective Analysis of Retinal Damage in HIV-positive Patients in the HAART Era Using OCT

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Abstract

PURPOSE—To assess retinal nerve fiber layer (RNFL) thickness in patients with human immunodeficiency virus (HIV) disease without cytomegalovirus retinitis (CMV).

DESIGN—A case-control study.

METHODS—The study included 113 eyes of 65 patients in one center. Thickness of RNFL along a 3.4-mm-diameter circle centered on the optic nerve head was evaluated using third-generation optical coherence tomography. Patients in group A (39 eyes of 22 patients) were human immunodeficiency virus-negative control subjects. Group B (36 eyes of 18 patients) was composed of HIV patients with no history of CMV retinitis and CD4 counts consistently above 100. Group C (38 eyes of 25 patients) comprised HIV patients with no history of CMV retinitis but a history of CD4 count less than 100 at some point lasting for at least 6 months.

RESULTS—The average RNFL thicknesses in groups A, B, and C were $103.33 \pm 8.50 \mu\text{m}$, $103.30 \pm 9.28 \mu\text{m}$, and $90.10 \pm 12.50 \mu\text{m}$, respectively. Group C had significantly thinner overall RNFL than either of the groups A and B (Tukey-Kramer). This difference was most prominent in temporal, superior, and inferior retinal areas. No difference was in nasal retinal area, nor between groups A and B in any of the areas.

CONCLUSIONS—Significant RNFL thinning occurs in HIV patients without CMV retinitis and with low CD4 counts compared with the same subgroup of patients with CD4 count increased to above 100 and HIV-negative control subjects. Third-generation OCT may be useful in diagnosis of early subclinical HIV-associated visual functional loss.

Highly active antiretroviral therapy (HAART) has decreased the incidence of cytomegalovirus (CMV) retinitis among patients with acquired immunodeficiency syndrome (AIDS) by approximately 75%.^{1,2} The most frequent posterior segment disease in patients infected with human immunodeficiency virus (HIV) is HIV retinopathy, an ischemic retinopathy ophthalmoscopically characterized by cotton-wool spots and intraretinal hemorrhages.³ Pepose and others⁴ have shown that in HIV-positive patients the microangiopathy leads to loss of inner retinal structures including the vasculature and ganglion cells and that this is associated with retinal capillary and vascular loss. Cotton-wool spots can be seen clinically in these patients and are more common as the immunodeficiency worsens.⁵

Previous studies have shown that individuals infected with HIV without infectious retinitis show deficits in visual function. Several groups, including our own, have demonstrated reduced sensitivity in the field of vision using both standard and short-wavelength perimetry,^{6,7} color and contrast sensitivity tests of central vision,^{8–11} and electrophysiological testing, which has suggested that there is a retinal component to the vision loss.^{12,13} Further studies by our group in the HIV-positive patient population without retinitis have shown that there are particular topographic patterns of this visual field loss.¹⁴

One hypothesis to explain this vision loss is that it may be due to permanent infarctions of the retinal nerve fiber layer (RNFL) from previously resolved cotton-wool spots, areas of retinal capillary dropout, or both. Previous studies by our group have shown at autopsy that HIV-positive patients have impressive axonal loss in the optic nerve; these studies examined optic nerve axon counts in HIV-positive patients without CMV retinitis and in HIV-negative patients.¹⁵ In HIV-positive patients without CMV retinitis, there is up to a 50% loss in nerve fiber population, notwithstanding the fact that the optic nerve clinically may appear normal.¹⁶ We have hypothesized that such loss of myelinated optic nerve fibers is secondary to the inner retinal damage caused directly or indirectly by HIV.

Previous studies from our laboratory using scanning laser ophthalmoscopy have shown that significant thinning of the RNFL occurs in HIV-positive patients without CMV retinitis.¹⁷ Using this technique, the peripapillary retina is sectioned in the Z-axis and retinal thickness calculated. We have demonstrated significant thinning of the RNFL in HIV-positive patients without infectious retinopathy as well as optic disk changes associated with CMV retinitis.

Recently, optical coherence tomography (OCT) has been introduced and shown to be useful clinically to detect RNFL defects in patients with glaucoma and other diseases.^{18,19} We hypothesized that third-generation OCT instrumentation would allow documentation and quantification of inner retinal loss in HIV patients without CMV retinitis and would allow longitudinal studies and determination of associated risk or causative factors of retinal damage in this population.

METHODS

Patient Population

Patients were recruited from the University of California, San Diego, AIDS Ocular Research Unit at the Jacobs Retina Center in La Jolla, California. Patients were enrolled in an Institutional Review Board–approved study of HIV disease, and informed consent for imaging and data collection was obtained from the patients. They had no history of ocular disease or surgery. The study included 113 eyes of 65 patients (55 men, 10 women) who were divided into three groups. One of the authors (WRF) reviewed medical data on HIV-positive patients without knowledge of scans to classify the patients into the three groups. Group A consisted of 39 eyes of 22 HIV-negative patients who served as normal control subjects. They had no history of ocular disease and the mean $\pm$ standard deviation (SD) age in this group was 38.22 ± 9.39 years. Group B consisted of 36 eyes of 18 HIV-positive patients with mean $\pm$ SD age of 41.77 ± 8.15 years. The data from their medical records showed that CD4 cell counts were never below 100 ($1.0 \times 10^9/L$) in these patients. They have had no significant ocular disease or eye surgery and served as positive control subjects. Included in group C were 38 eyes of 25 HIV-positive patients (mean $\pm$ SD age of 41.64 ± 6.61 years) with CD4 cell counts below 100 at some point of time in their medical history lasting for at least 6 months. All patients were treated with HAART therapy prior to and at the time of the examination. Concurrent or healed CMV retinitis in an eye was an exclusion criterion; however, fellow eyes of CMV retinitis were included.

Imaging Studies

The patients had complete ophthalmologic examinations including indirect ophthalmoscopy and standardized retinal photography with a wide-angle fundus camera using overlapping fields as previously described.²⁰ Retinal NFL imaging was performed by one of the authors (I.K.) using the Stratus OCT Model 3000 (Carl Zeiss Meditec, Dublin, California, USA). This model uses a light emitting diode (LED) emitting low coherence infrared illumination (820 nm) that generates cross sectional images of the retina with <10 microns axial resolution. For each A-scan, the Stratus OCT acquires a fixed number of 1,024 axial data points along the 2 mm depth. The total number of A-scans is 512/B-scan done in 1.28 seconds. The older versions of OCT required dilation with at least a 5-mm pupil. The newer Stratus OCT adequately visualizes ocular fundus with 3-mm pupil and in many individuals does not require pupillary dilation. This was much appreciated in control subjects in group A.

The RNFL is differentiated from other retinal layers using a threshold algorithm that detects the separation between the first highly reflective layer (anterior edge of the internal limiting membrane) and the posterior edge of the first highly reflective layer (posterior edge of the RNFL). The “RNFL Thickness (3.4)” protocol enables us to acquire three circle scans with a diameter of 3.4 mm around the optic disk (Figure 2). The scans were well centered at the optic nerve head. Measurements of RNFL thickness from 3 scans were averaged to provide a mean measurement of the overall RNFL thickness as well as the following retinal regions: temporal (316 degrees to 45 degrees on a unit circle), superior (46 degrees to 135 degrees on a unit circle), nasal (136 degrees to 225 degrees on a unit circle), and inferior (226 degrees to 315 degrees on a unit circle).

Statistics

Continuous data such as retinal thickness, age, and refraction were compared among groups using the Tukey-Kramer Honestly Significant Difference test; categorical data such as gender and ethnicity were tabulated and compared among groups using the chi-square test. A *P* value of less than .05 was considered statistically significant.

RESULTS

Table 1 shows the demographics of the subjects. All groups in the study were matched for age ($p = 0.67$), sex ($p = 0.82$), and ethnic/racial distribution ($p = 0.22$). There were no differences among groups in refraction ($p = 0.17$).

Peripapillary OCT RNFL measurements in all groups are presented in Table 2. Statistically significant difference has been observed in overall RNFL thickness between groups A and C ($P < .001$) and between groups B and C ($P < .001$). There was no difference in mean RNFL measurements between groups A and B ($P > .05$).

Analysis of RNFL thickness in the specified quadrants of the eyes revealed a characteristic double-hump pattern with RNFL peaks in the superior and inferior retinal areas and troughs in the temporal and nasal areas in all diagnostic groups. Further significance was observed in comparing these separate retinal areas between the three patient groups (Figure 1). Group C differed from groups A and B in temporal, superior, and inferior areas for RNFL thickness, respectively ($P < .05$, $P < .01$, and $P < .001$) (Figure 3). No statistical significance was present in RNFL thickness values in the nasal area among the groups. There was no differences in RNFL thickness between groups A and B in any particular retinal area (quadrants).

There was clear predominance of male subjects in all diagnostic groups and Hispanic patients in the HIV-positive group with low CD4 counts. We therefore compared the overall RNFL thickness between our Hispanic cohort (n = 10) and a non-Hispanic cohort (n = 12) within our control group A to see whether the former had thinner NFL than other ethnicities. The mean overall RNFL in the Hispanic vs non-Hispanic subgroups were $104.02 \pm 6.07 \mu\text{m}$ and $103.78 \pm 6.95 \mu\text{m}$, respectively, which was not significantly different from each other ($P > .5$). Similarly, there was no difference between the two subgroups in analysis of RNFL by retinal area (quadrants; $P > .5$).

We repeated our analysis of RNFL in groups of HIV-negative control subjects, high CD4, and low CD4 HIV-positive patients, excluding Hispanic patients. The overall RNFL thickness results are similar to our analysis, which included the cohort of Hispanic patients. The overall RNFL thickness with Hispanics excluded was $104.51 \pm 10.12 \mu\text{m}$ in HIV-negative group (n = 12), $105.67 \pm 11.87 \mu\text{m}$ in high CD4 HIV-positive group (n = 10), and $91.40 \pm 16.39 \mu\text{m}$ in low CD4 HIV-positive group (n = 9); the last value was significant ($P < .05$) compared with the previous two. However, there was no difference between the three subgroups in analysis of RNFL by retinal area (quadrants) ($P > .05$).

DISCUSSION

Advances in ocular imaging technology have made it possible to evaluate the RNFL thickness in an objective, quantifiable, and reproducible fashion.^{19,21,22} OCT, which uses short coherence length interferometer, has a fine resolution (cca $10 \mu\text{m}$) and reflects the histologic characteristics of the tissue. Because OCT is based on cross-sectional images of the retina, the instrument measures the retinal NFL directly, has no need for a reference plane, and is known to be unaffected by the refractive status, axial length of the subject, sclerosis of the lens,²³ or pupillary dilation.^{24,25} The only limitations of OCT imaging are the uncertainty of the assumed group refractive index of tissue, the effect of eye movements during the B-scan location, and the interface detection artifacts.²⁶ To avoid any influence of eye movements, we observed the scanned eye during B-scan and repeated the scan if we noticed any eye movement. To avoid software interface detection artifacts, we inspected every B-scan after acquisition and repeated the scan if the software was unable to detect the RNFL borders.

Using the third-generation OCT (Stratus OCT Model 3000) in this study, we were able to detect significant decreases in RNFL thickness measurements in HIV-positive compared with HIV-negative patients as well as differences between subgroups of HIV-positive patients who differed in the history of their CD4 cell counts. Our observations offer further evidence of ongoing RNFL damage in a portion of HIV-positive patients without history of CMV retinitis. This portion of HIV-positive patients appeared to have decreased CD4 cell counts to <100 lasting for at least 6 months at any time in their medical history. In contrast, the HIV-positive patients whose CD4 cell counts never dropped to below 100 had overall RNFL thickness not significantly from our control HIV-negative population.

Although we know the date of diagnosis of HIV positivity, some patients on presentation have had HIV for many years. In longitudinal observations, there is no reliable way of knowing the sickness of HIV patients except for regular CD4 cell counts. More important to retinal damage may be knowledge of the duration of low CD4 cell counts and integrated viral load. Therefore, we reviewed all patients in masked fashion and classified them based on the history of their CD4 cell counts. We are aware that there are other parameters in HIV patients that may correlate with RNFL loss, including viral load, duration of viral load over time, time since HIV seroconversion, neuropsychic tests, and, potentially, other methods including cerebrospinal fluid data. Although we have some of these data on a small number

of our patients at the moment, we do not have sufficient data for our analysis. However, we plan to expand our cohort.

Our study cohort contained majority of Hispanic male patients with potential for ethnic bias. However, subanalysis of Hispanic vs non-Hispanic HIV-negative control subjects did not reveal differences in RNFL thickness. Further analysis among our three groups excluding Hispanic patients confirmed the same results in overall RNFL thickness, thus showing similar findings for other ethnic groups represented.

Our results of overall RNFL thickness and thickness measurements in particular retinal areas using the new generation OCT are consistent with previous reports using a default scan diameter of 3.4 mm from the center of the optic nerve head^{23,27-29} (RM Vessani, Retinal nerve fiber layer thickness measured by OCT3 and central corneal thickness in ocular hypertensive patients, ARVO 2004, paper #3407). The RNFL was thickest in the superior and inferior retinal areas and thinner in the temporal and nasal ones, which is in agreement with other studies.^{30,31} Schuman and associates,³⁰ Bowd and associates,³¹ and Liu and associates²⁷ reported a difference between the nasal and temporal RNFL thickness, with the nasal quadrant thinner than the temporal quadrant. However, we found that the temporal RNFL thickness had a tendency to be thinner than the nasal quadrant. Similar to our results, observations between these two retinal areas that reached statistical significance, however, were described in works by Varma³² and later reports by Schuman²³ and are also supported by histologic data.³³

We emphasize that there is a scarcity of published work on normal RNFL thickness using third-generation OCT. Because of its improved resolution, the anterior and posterior borders of RNFL are apt to be better defined. This is likely to have an effect on the normal database. The RNFL thickness of our HIV-negative patients fell within normal range of instrument's database, thus validating our study. The RNFL thickness values of our HIV-positive patients with low CD4 counts fell within the low range of manufacturer values but it was usually outside that of our contemporaneous normal controls.

In this study, the difference between low CD4 HIV-positive and high CD4 HIV-positive/HIV-negative groups was most prominent in superior and inferior retinal areas and less pronounced but still statistically significantly different in the temporal retinal area. The nasal retinal area showed no significant thinning among the groups. Interestingly, the areas of RNFL thinning in our low CD4 HIV-positive patients correspond with the distribution of cotton-wool spots in patients with AIDS as described by Mansour and associates³⁴ In their original report, the cotton-wool spots in AIDS patients had a strong predilection for the posterior pole and were present predominantly along the vascular arcades with 30.9%, 38.9%, 20.1%, and 10.1% of all those occurring in the superotemporal, inferotemporal, superonasal, and inferonasal quadrants, respectively. A previous report on pattern of early visual field loss in HIV-positive patients without CMV retinitis revealed involvement of superior and inferior regions of the visual field,¹⁴ which also correlates with thinning of RNFL in corresponding retinal areas in this study. Ongoing studies in our center are employing psychophysical and other imaging studies to examine vision loss in this population of patients.

Because clinically we see a similar distribution of cotton-wool spots in our HIV-positive patients with low CD4 cell counts, we assume that these retinal microinfarctions are responsible for subsequent defects in RNFL thickness. Indeed, histopathologic studies showed significance of cotton-wool spots in pathogenesis of retinal neural tissue loss.^{4,15} It would be interesting to know whether visual dysfunction that we and other groups have

found in HIV-positive patients without CMV retinitis correlates with RNFL loss. This will be the subject of further study.

We conclude that significant thinning of the RNFL occurs in HIV-positive patients without a history of CMV retinitis and with a history of low CD4 cell counts in comparison to the same group of patients with CD4 cell count increased above 100 and HIV-negative control subjects. Third-generation OCT better reflects the true RNFL thickness and may be of clinical use in the diagnosis of early subclinical HIV-associated visual functional loss.

References

1. Jabs DA, Van Natta ML, Kempen HJ, et al. Characteristics of patients with cytomegalovirus retinitis in the era of highly active antiretroviral therapy. *Am J Ophthalmol.* 2002; 133:48–61. [PubMed: 11755839]
2. Jacobson MA, Stanley H, Holtzer C, et al. Natural history and outcomes of new AIDS-related cytomegalovirus retinitis diagnosed in the era of highly active antiretroviral therapy. *Clin Infect Dis.* 2000; 30:232–233.
3. Kupperman BD, Petty JG, Richman DD, et al. The correlation between CD4+ counts and the prevalence of cytomegalovirus retinitis and human immunodeficiency virus-related non-infectious retinal vasculopathy in patients with acquired immunodeficiency syndrome. *Am J Ophthalmol.* 1993; 115:575–582. [PubMed: 8098183]
4. Pepose JS, Holland GN, Nestor MS, et al. Acquired immunodeficiency syndrome. Pathogenic mechanisms of ocular disease. *Ophthalmology.* 1985; 92:472–484. [PubMed: 2987769]
5. Freeman WR, Chen A, Henderly DE, et al. Prevalence and significance of acquired immunodeficiency syndrome-related retinal microvasculopathy. *Am J Ophthalmol.* 1989; 107:229–235. [PubMed: 2522276]
6. Plummer DJ, Sample PA, Arevalo JF, et al. Visual field loss in HIV-positive patients without infectious retinopathy. *Am J Ophthalmol.* 1996; 122:542–549. [PubMed: 8862052]
7. Geier SA, Nohmeier C, Lachenmayr BJ, et al. Deficits in perimetric performance in patients with symptomatic human immunodeficiency virus infection or acquired immunodeficiency syndrome. *Am J Ophthalmol.* 1995; 119:335–344. [PubMed: 7872396]
8. Quinceno JJ, Capparelli E, Sadun AA, et al. Visual dysfunction without retinitis in patients with acquired immunodeficiency syndrome. *Am J Ophthalmol.* 1992; 113:8–13. [PubMed: 1728151]
9. Mueller AJ, Plummer DJ, Dua R, et al. Analysis of visual dysfunctions in HIV-positive patients without retinitis. *Am J Ophthalmol.* 1997; 124:158–167. [PubMed: 9262539]
10. Geier SA, Kronawitter U, Bogner JR, et al. Impairment of color contrast sensitivity and neuroretinal dysfunction in patients with symptomatic HIV infection or AIDS. *Br J Ophthalmol.* 1993; 77:716–720. [PubMed: 8280686]
11. Geier SA, Hammel G, Bogner JR, et al. HIV-related ocular microangiopathic syndrome and color contrast sensitivity. *Invest Ophthalmol Vis Sci.* 1994; 35:3011–3021. [PubMed: 8206718]
12. Iragui VJ, Kalmijn J, Plummer DJ, et al. Pattern electroretinograms and visual evoked potentials in HIV infection: evidence for asymptomatic retinal and postretinal impairment in the absence of infectious retinopathy. *Neurology.* 1996; 47:1452–1456. [PubMed: 8960726]
13. Latkany PA, Holopigian K, Lorenzo-Latkany M, et al. Electro-retinographic and psychophysical findings during early and late stages of human immunodeficiency virus infection and cytomegalovirus retinitis. *Ophthalmology.* 1997; 104:445–453. [PubMed: 9082271]
14. Sample PA, Plummer DJ, Mueller AJ, et al. Pattern of early visual field loss in HIV-infected patients. *Arch Ophthalmol.* 1999; 117:755–760. [PubMed: 10369585]
15. Tenhula WN, Xu SZ, Madigan MC, et al. Morphometric comparisons of optic nerve axon loss in acquired immunodeficiency syndrome. *Am J Ophthalmol.* 1992; 113:14–20. [PubMed: 1370189]
16. Freeman WR, Chen A, Henderly DE, et al. Prevalence and significance of acquired immunodeficiency syndrome-related retinal microvasculopathy. *Am J Ophthalmol.* 1989; 15:107:229–235. [PubMed: 2522276]

17. Plummer DJ, Bartsch DU, Azen SP, et al. Retinal nerve fiber layer evaluation in human immunodeficiency virus-positive patients. *Am J Ophthalmol.* 2001; 131:216–222. [PubMed: 11228298]
18. El Beltagi TA, Bowd C, Boden C, et al. Retinal nerve fiber layer thickness measured with optical coherence tomography is related to visual function in glaucomatous eyes. *Ophthalmology.* 2003; 110:2185–2191. [PubMed: 14597528]
19. Jaffe GJ, Caprioli J. Optical coherence tomography to detect and manage retinal disease and glaucoma. *Am J Ophthalmol.* 2004; 137:156–169. [PubMed: 14700659]
20. The Studies of Ocular Complications of AIDS Research Group in Collaboration with the AIDS Clinical Trials Group. Assessment of cytomegalovirus retinitis—Clinical evaluation vs centralized grading of fundus photographs. *Arch Ophthalmol.* 1996; 114:791–805.
21. Huang D, Swanson EA, Lin CP, et al. Optical coherence tomography. *Science.* 1991; 254:1178–1181. [PubMed: 1957169]
22. Hee MR, Izatt JA, Swanson EA, et al. Optical coherence tomography of the human retina. *Arch Ophthalmol.* 1995; 113:325–332. [PubMed: 7887846]
23. Schuman JS, Pedut-Kloizman T, Hertzmark E, et al. Reproducibility of nerve fiber layer thickness measurements using optical coherence tomography. *Ophthalmology.* 1996; 103:1889–1898. [PubMed: 8942887]
24. Wang RC, Koozekanani D, Herderick EE, et al. Effect of pupil dilatation and scanning power on retinal thickness measurements using optical coherence tomography. *Invest Ophthalmol Vis Sci.* 2000; 41:1486–1491. [PubMed: 10798667]
25. Zafar S, Gurses-Ozden R, Vessani R, et al. Effect of papillary dilation on retinal nerve fiber layer thickness measurements using optical coherence tomography. *J Glaucoma.* 2004; 13:34–37. [PubMed: 14704541]
26. Ishikawa H, Piette S, Liebmann JM, et al. Detecting the inner and outer borders of the retinal nerve fiber layer using optical coherence tomography. *Graefes Arch Clin Exp Ophthalmol.* 2002; 240:362–371. [PubMed: 12073059]
27. Liu X, Ling Y, Luo R, et al. Optical coherence tomography in measuring retinal nerve fiber layer thickness in normal subjects and patients with open-angle glaucoma. *Chin Med J.* 2001; 114:524–529. [PubMed: 11780419]
28. Alamouti B, Funk J. Retinal thickness decreases with age: An OCT study. *Br J Ophthalmol.* 2003; 87:899–901. [PubMed: 12812895]
29. Hougaard JL, Kessel L, Snader B, et al. Evaluation of heredity as a determinant of retinal nerve fiber layer thickness as measured by optical coherence tomography. *Invest Ophthalmol Vis Sci.* 2003; 44:3011–3016. [PubMed: 12824246]
30. Schuman JS, Hee MR, Puliafito CA, et al. Quantification of nerve fiber layer thickness in normal and glaucomatous eyes using optical coherence tomography. *Arch Ophthalmol.* 1995; 113:586–596. [PubMed: 7748128]
31. Bowd C, Weinreb RN, Williams JM, Zangwill LM. The retinal nerve fiber layer thickness in ocular hypertensive, normal, and glaucomatous eyes with optical coherence tomography. *Arch Ophthalmol.* 2000; 118:22–26. [PubMed: 10636409]
32. Varma R, Bazzaz S, Lai M. Optical tomography-measured retinal nerve fiber layer thickness in normal Latinos. *Invest Ophthalmol Vis Sci.* 2003; 44:3369–3373. [PubMed: 12882783]
33. Varma R, Skaf M, Barron E. Retinal nerve fiber layer thickness in normal human eyes. *Ophthalmology.* 1996; 103:2114–2119. [PubMed: 9003346]
34. Mansour AM, Jampol LM, Logani S, et al. Cotton wool spots in acquired immunodeficiency syndrome compared with diabetes mellitus, systemic hypertension, and central retinal vein occlusion. *Arch Ophthalmol.* 1988; 106:1074–1077. [PubMed: 3401133]

FIGURE 1.

Optical coherence tomography (OCT) scans of the eye of a human immunodeficiency virus (HIV)-negative control (top), HIV-positive patient with high CD4 cells count (middle), and HIV-positive patient with a history of low CD4 cells count (bottom). Normalized and aligned scans identify outer and inner layers of the retinal nerve fiber layer (RNFL). Normalization and alignment is processed by OCT software not the operator.

FIGURE 2.

Example of location of circumpapillary retinal nerve fiber layer scan from left eye of a human immunodeficiency virus (HIV)-negative patient. During the examination operator ensured exact motion-free centration.

FIGURE 3.

Graphic depiction of retinal nerve fiber layer (RNFL) in HIV-negative (green line), HIV-positive high CD4 (red line), and HIV-positive low CD4 count (blue line) patients. Mean RNFL thickness in these patients' eyes is 104, 101, and 87 μm , respectively.

TABLE 1

Demographic Data of Subgroups

	Group A (n =22)	Group B (n =18)	Group C (n =25)
Number of eyes	39	36	38
Age (years), mean $\pm$ SD	38.22 $\pm$ 9.39	41.77 $\pm$ 8.15	41.64 $\pm$ 6.61
Male/female	18/4	15/3	22/3
Refraction (diopters), mean $\pm$ SD	-1.37 $\pm$ 1.14	-0.88 $\pm$ 1.45	-0.64 $\pm$ 1.21
Ethnic/racial background			
Caucasian	8	7	8
African American	1	3	1
Hispanic	10	7	16
Asian	2	0	0
Other	1	0	0

HIV = human immunodeficiency virus. Group A = HIV-negative subjects; group B = HIV-positive patients with high CD4 counts; group C = HIV-positive with low CD4 counts.

TABLE 2

Retinal Nerve Fiber Layer Thickness in Eyes (n) of Subgroups

Retinal area	Group A (n = 39)	Group B (n = 36)	Group C (n = 38)	P Value
Temporal	75.89 ± 17.69	73.22 ± 14.69	65.15 ± 16.93	<.05 [†]
Superior	122.69 ± 12.67	127.47 ± 17.59	110.28 ± 20.71	<.01 [†]
Nasal	78.28 ± 15.09	74.58 ± 15.44	72.21 ± 12.44	>.05
Inferior	137.20 ± 17.47	138.55 ± 14.29	112.42 ± 22.92	<.001 [†]
Overall	103.33 ± 8.50	103.30 ± 9.28	90.10 ± 12.50	<.001 [†]

* Values are expressed in micrometers as mean ± SD.

[†] Group C statistically is different from Group A and B (Tukey-Kramer Honestly Significant Difference test, $P < .05$)

[‡] All diagnostic groups significantly different from each other (Tukey-Kramer Honestly Significant Difference test, $P < .05$)