Retinal and Choroidal Changes in Men Compared with Women with Alzheimer's Disease

A Case-Control Study

Delaram Mirzania, MD,[1,2] *Atalie C. Thompson, MD, MPH,*[1,2] *Cason B. Robbins, MD,*[1,2]
Srinath Soundararajan, BS,[1,2] *Jia Min Lee, PhD,*[3] *Rupesh Agrawal, MD,*[3] *Andy J. Liu, MD, PhD,*[1,4]
Kim G. Johnson, MD,[1,4] *Dilraj S. Grewal, MD,*[1,2,*] *Sharon Fekrat, MD*[1,2,*]

Purpose: To evaluate differences in the retinal microvasculature and structure and choroidal structure among men and women with Alzheimer's disease (AD) compared with age-matched cognitively normal male and female controls.

Design: Case-control study of participants $\geq$ 50 years of age.

Participants: A total of 202 eyes of 139 subjects (101 cases and 101 controls).

Methods: All participants and controls underwent OCT and OCT angiography (OCTA), and parameters of subjects with AD were compared with those of cognitively normal controls.

Main Outcome Measures: The foveal avascular zone (FAZ) area, vessel density (VD), and perfusion density (PD) in the superficial capillary plexus within the 3- and 6-mm circle and ring using Early Treatment Diabetic Retinopathy Study (ETDRS) grid overlay on OCTA; central subfield thickness (CST), retinal nerve fiber layer (RNFL) thickness, ganglion cell-inner plexiform layer (GCIPL) thickness, and choroidal vascularity index (CVI) on OCT.

Results: No significant sex differences in VD or PD were found in the AD or control cohorts; however, there were greater differences in VD and PD among AD female participants than AD male participants compared with their respective controls. The CST and FAZ area were not different between male and female AD participants. Among controls, men had a thicker CST ($P < 0.001$) and smaller FAZ area ($P = 0.003$) compared with women. The RNFL thickness, GCIPL thickness, and CVI were similar among male and female AD participants and controls.

Conclusions: There may be a loss of the physiologic sex-related differences in retinal structure and microvasculature in those with AD compared with controls. Further studies are needed to elucidate the pathophysiological basis for these findings. *Ophthalmology Science 2022;2:100098 © 2021 by the American Academy of Ophthalmology. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).*

Alzheimer's disease (AD), the most common type of dementia, is estimated to affect 13.8 million people by 2050.[1] Currently, there are no disease-modifying therapies and associated costs are expected to increase.[1] Retinal imaging is being increasingly investigated as a potential noninvasive method to understand neuropathological and microvascular changes in AD. Previously, we have shown that OCT findings such as ganglion cell-inner plexiform layer (GCIPL) thickness and OCT angiography (OCTA) findings such as macular vessel density (VD) and perfusion density (PD) in the superficial capillary plexus (SCP) are significantly decreased in AD patients compared with those with mild cognitive impairment or cognitively healthy subjects.[2] Other studies have demonstrated decreased retinal nerve fiber layer (RNFL) thickness[3-6] and decreased macular thickness with subsequent thinning of the peripapillary optic nerve fiber layer[7-10] in individuals with AD. Likewise,

differences exist in choroidal thickness,[11,12] macular volume,[4] and GCIPL thickness[5,6] in AD patients; however, none of these studies examined whether patient sex affected these retinal imaging findings.

Women comprise two-thirds of people living with AD, regardless of age.[13] In a recent review, Nebel et al[14] called for further exploration of the impact of sex differences on the clinical presentation, risk factors, and treatment of AD. They outlined 12 priority areas in sex differences in AD clinical research, including "clinical detection, diagnosis, management, and treatment of AD for both sexes."[14] Women have not only a higher prevalence and severity of AD but also greater postmortem AD pathology.[13,15] Because neuropathological changes of AD in the brain have also been observed in the retina,[16] it is possible that sex differences in AD may also be exhibited in the retina. Therefore, it is important to learn more about the

relationship between patient sex and retinal characteristics in AD to guide clinical and scientific approaches toward the development of ocular biomarkers for detection and monitoring of AD. In the current study, we evaluated patient sex differences in OCT and OCTA findings in individuals with AD compared with cognitively normal controls.

Methods

The Institutional Review Board at the Duke University School of Medicine approved this case-control study (Clinicaltrials.gov identifier, NCT03233646), which adhered to the Declaration of Helsinki tenets and complied with the Health Insurance Portability and Accountability Act. All participants or their designated medical power of attorney provided written informed consent before enrollment.

Participants

Participants included patients aged 50 years or older at the Duke Memory Disorders Clinic with a diagnosis of AD according to diagnostic guidelines set forth by the National Institute on Aging-Alzheimer's Association,[17] after evaluation by expert clinicians specialized in memory disorders. Before data analysis, an expert neurologist (A.J.L.) reviewed study participants' medical records for clinical history, cognitive testing, and neuroimaging to ensure diagnostic accuracy. Brain positron emission tomography or lumbar puncture for AD biomarker status assessment was not performed, because these are not part of routine clinical assessment at our institution. Participants' cognitive function was evaluated via a Mini-Mental State Examination (MMSE) on the same day as image acquisition. Years of education, defined as number of years from the first grade, were collected at enrollment. Participants were excluded if they had diabetes mellitus, non-AD dementia, uncontrolled hypertension, age-related macular degeneration, suspected or diagnosed glaucoma, corrected visual acuity < 20/40 at the time of imaging, significant media opacity, and other vitreoretinal pathologic features that could confound OCT or OCTA analysis. The control group consisted of healthy volunteers aged ≥ 50 years with no self-reported memory symptoms. Control participants were spouses or caretakers of patients at the Duke Memory Disorders clinic or part of the cohort from the Bryan Alzheimer's Disease Research Center Registry comprised of well-characterized cognitively normal controls.

OCT and OCTA Imaging and Protocol

All subjects were imaged using the Zeiss Cirrus HD-5000 with AngioPlex (Carl Zeiss Meditec, Software Version 11.0.0.29946) that used motion tracking with a 68 000 A-scan per second scan rate and 840 nm central wavelength.[18]

OCTA parameters were assessed using 6 × 6-mm and 3 × 3-mm OCTA images centered on the fovea. The VD was defined as the total length of perfused vasculature per unit area, whereas PD was defined as the total area of perfused vasculature per unit area. As illustrated in Figure 1, VD and PD were measured over the 3-mm Early Treatment Diabetic Retinopathy Study (ETDRS) circle and ring (using a 3 × 3-mm OCTA scan protocol) and 6-mm ETDRS circle and the inner and outer rings (using a 6 × 6-mm OCTA scan protocol). The boundaries of the foveal avascular zone (FAZ) were automatically determined (using the 3 × 3-mm OCTA scan) and then manually reviewed to correct inaccurate boundaries or exclude those that could not be corrected.

OCT image acquisition included a 200 × 200 optic disc cube, a 512 × 128 macular cube (6-mm square grid with 128 horizontal scan lines each composed of 512 A-scans using a 47-μm spacing between lines and 1024 data points per A scan), and a 21-line enhanced depth imaging raster scan. A 14.13-mm² elliptical annulus area that was centered on the fovea was used to quantify the average GCIPL thickness. Central subfield thickness (CST) was defined as the distance between the retinal pigment epithelium and the inner limiting membrane at the fovea on the macular cube scan (Fig 2). Thickness of the RNFL was automatically quantified by centering a 3.46-mm diameter circle on the optic disc to calculate average RNFL thickness and RNFL thickness in 4 sectors (superior, inferior, temporal, nasal).

Total choroidal area (TCA), luminal area (LA), and choroidal vascularity index (CVI) were measured on the basis of methods described by Agrawal et al[19] (Fig 3). Public domain software ImageJ (National Institutes of Health) was used to perform image binarization. The TCA was selected using polygon tool and subsequently added in the region of interest manager. The image was converted into 8 bit, and Niblack auto local thresholding was applied; this provided the mean pixel value and standard deviation for all the points. The LA was highlighted by applying color threshold on the enhanced depth imaging foveal scans. Using the "AND" operation of ImageJ, both the areas in ROI manager were selected and merged to determine the LA within the selected polygon. The CVI was determined by dividing LA by TCA. All images were manually reviewed for quality, and any image that had less than 7/10 signal strength or artifact that would interfere with image analysis was omitted.[2]

Statistical Analysis

Cases and controls were age matched (50−54, 55−59, 60−64, 65−69, 70−74, 75−79, 80−84, ≥85 years) in a 1-to-1 ratio. Continuous data were presented as mean (± standard deviation). Generalized estimating equations (GEE) were used to generate a P value for the following comparisons: (1) male AD versus female AD participants, (2) male controls versus female controls, (3) female AD participants versus female controls, (4) male AD participants versus male controls. The distribution was Gaussian with an exchangeable correlation. The dependent variable in the model was the individual OCT or OCTA parameter. For each parameter and comparison group, a separate GEE model was run. If both eyes were available, they were included and controlled for in the GEE model. A tobit regression model was used to compare the baseline MMSE score between men and women. A P value less than 0.05 was considered statistically significant. All statistical analyses were completed in STATA software version 15.1 (StataCorp, LP).

Results

A total of 202 eyes of 139 patients were included, and 76 eyes were excluded because they did not comply with inclusion criteria. Patient demographics are summarized in Table 1. A total of 101 eyes of 59 AD patients (18 men, 41 women) and 101 eyes of 80 control subjects (27 men, 53 women) were imaged. A total of 129 patients were White (77 controls, 52 AD), and 2 patients were Black (0 controls, 2 AD). The remaining 8 patients were other or unreported race (3 controls, 5 AD). The average age of each subgroup was similar to all the others at 73 years old. The average MMSE scores were similar between male and female AD patients (23 vs. 21, $P = 0.19$). The
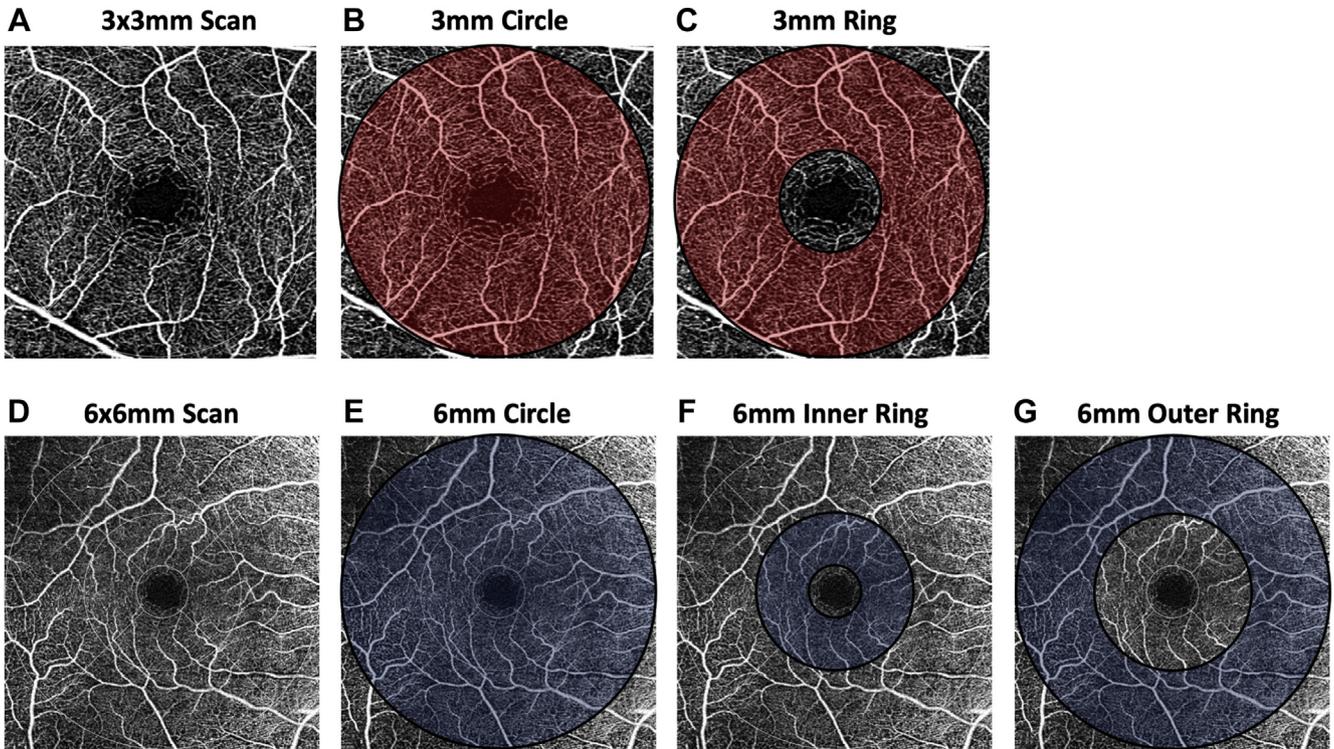
Figure 1. OCT angiography (OCTA) 3 × 3-mm protocol was used to obtain **(A)** 3 × 3-mm scan. Vessel density (VD) and perfusion density (PD) were averaged over the area highlighted in red using Early Treatment Diabetic Retinopathy Study (ETDRS) grid regions for **(B)** 3-mm circle and **(C)** 3-mm ring. OCTA 6 × 6-mm protocol was used to obtain **(D)** 6 × 6-mm scan, and the VD and PD were averaged over the area highlighted in blue using ETDRS grid regions for **(E)** 6-mm circle, **(F)** 6-mm inner ring, and **(G)** 6-mm outer ring.

OCT and OCTA parameters are summarized in Tables 2 and 3.

In the AD cohort, there were no differences among men and women for VD or PD in the 3-mm circle or ring, 6-mm circle, and 6-mm inner or outer rings (Table 2). The CST ($P = 0.81$), FAZ area ($P = 0.24$), and average RNFL thickness ($P = 0.89$) were also similar across AD male and female participants. The GCIPL thickness was higher in AD female participants compared with AD male participants, but it only approached statistical significance (72.8 ± 8.1 μm vs. 67.9 ± 2.5 μm, $P = 0.054$). There was no difference between men and women in TCA, LA, or CVI (Table 3).

When comparing the control groups with each other, there are only significant differences in CST and FAZ. In the control group, men had a significantly thicker CST compared with women ($P < 0.001$). The FAZ area was significantly smaller in male controls compared with female controls ($P = 0.003$). No significant differences were found among men and women for VD or PD in the 3-mm circle or ring, 6-mm circle, and 6-mm inner or outer rings (Table 2). Average RNFL thickness ($P = 0.22$) and average GCIPL thickness ($P = 0.43$) were similar between male and female controls.

When comparing female AD participants versus female controls, the AD group had a significantly lower 3-mm circle PD ($P = 0.009$), 3-mm ring PD ($P = 0.005$), 3-mm circle VD ($P = 0.01$), and 3-mm ring VD ($P = 0.008$).

Average RNFL thickness ($P = 0.04$) and GCIPL thickness ($P = 0.002$) were significantly lower in the female AD group compared with the female control group. On choroidal image analysis, there was no difference between the female groups for TCA, LA, and CVI (Table 3).

In the male AD versus male control analysis, the AD group demonstrated a significantly lower 6-mm circle VD ($P = 0.04$) and GCIPL thickness ($P = 0.001$). There was no statistical significance between the 2 male groups in 3-mm circle PD ($P = 0.52$), 3-mm ring PD ($P = 0.55$), 3-mm circle VD ($P = 0.08$), 3-mm ring VD ($P = 0.08$), RNFL thickness ($P = 0.67$), CST ($P = 0.11$), and FAZ area ($P = 0.27$).

Discussion

We investigated the effects of patient sex differences on the neuronal layers, retinal microvasculature, and choroidal structure in AD patients using OCT and OCTA imaging to help clarify whether sex differences in neuronal loss of the brain parenchyma[15,16] are also observed in the retina.[20] Our findings can be summarized as follows: (1) There is no difference between male and female AD patients in retinal microvasculature (SCP VD and PD, FAZ area), retinal structure (RNFL thickness and GCIPL thickness), or choroidal parameters (TCA, LA, and CVI); (2) there is no difference between cognitively normal male and female
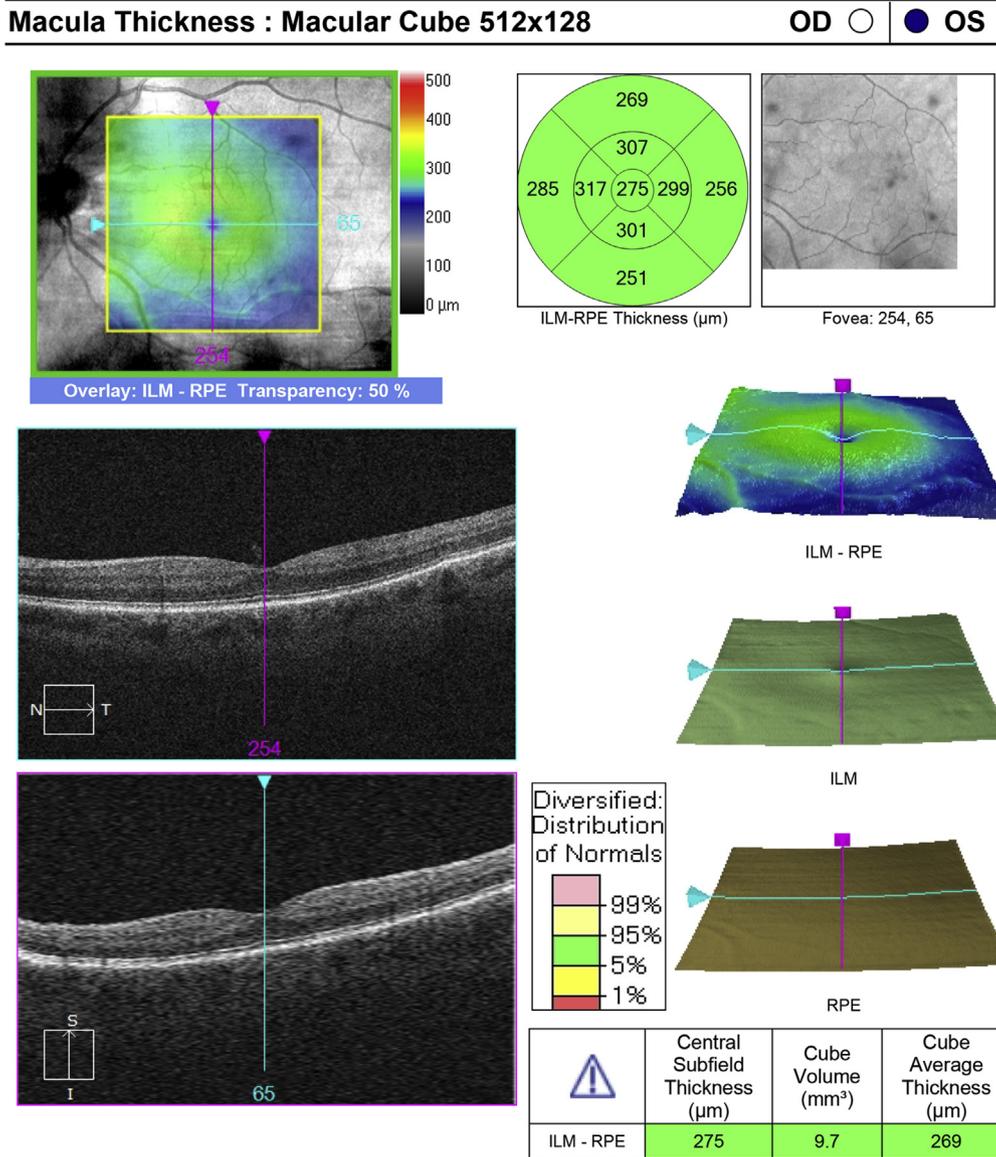
Figure 2. A 512 × 128 macular cube image with ETDRS grid overlay demonstrating automatic segmentation of the retinal pigment epithelium and internal limiting membrane by the Zeiss software (Carl Zeiss Meditec, Software Version 11.0.0.29946) to calculate central subfield thickness (CST) as defined by the distance between the retinal pigment epithelium and internal limiting membrane at the fovea. ETDRS = Early Treatment Diabetic Retinopathy Study; ILM = internal limiting membrane; OD = right eye; OS = left eye; RPE = retinal pigment epithelium.

subjects in VD and PD, and GCIPL thickness; (3) in the control cohort, women had a larger FAZ area and a thinner CST compared with men; (4) GCIPL thickness was significantly thinner in AD male and AD female participants compared with their respective controls; (5) differences found in VD and PD in 3-mm circle and ring for female AD versus female controls were not found in male AD versus male controls.

In the present study, we demonstrated that patient sex is not associated with retinal microvascular density in AD patients. This has important clinical implications because it suggests that there may not be a differential measurable sex-related impact on retinal neurodegenerative and microvasculature changes in AD. Our group has previously demonstrated that patients with AD have decreased SCP PD and VD in both the 3-mm and 6-mm scans using the ETDRS subfield overlay.[2] Reduced retinal capillary density in AD has also been demonstrated;[21,22] however, the role of patient sex in these observations has not been specifically evaluated. In this study, we did not find a difference in VD and PD in either the 3-mm or 6-mm scans in AD female versus AD male participants.

Although our findings suggest that the retinal microvascular pathology seen in patients with AD may be independent of patient sex, we did observe significantly decreased VD and PD in the 3-mm circle and ring in female AD
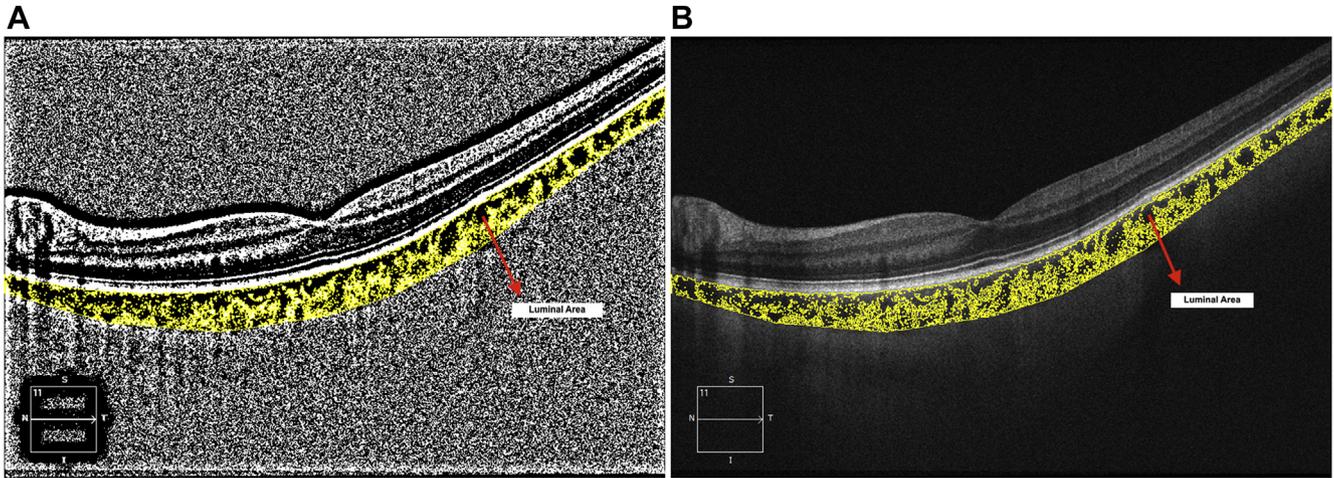
A
B

Figure 3. Total choroidal area (TCA) (**yellow highlight**) and luminal area (LA) (**red arrow**) were measured using a binarized image (**A**). **B,** The LA overlayed on an OCT scan is demonstrated. Choroidal vascularity index (CVI) was determined by dividing TCA by LA.

patients compared with female control patients, whereas this effect was not present in the comparison between male AD participants and male controls. This may suggest a greater impact of AD-related neurodegenerative changes in the retina in female compared with male participants. This merits further investigation to determine if separate sex-based threshold cutoffs for categorizing observed retinal vascular changes may be beneficial in the future. Female sex is well recognized to be a major risk factor for developing late-onset AD.[23] Brain imaging studies have found that 40- to 60-year-old women exhibit an AD phenotype characterized by decreased metabolic activity (including reduced glucose metabolism and mitochondrial function) and increased brain amyloid-beta deposition compared with both younger women and age-matched men.[24] Nonetheless, we did not find a significant difference in male AD versus female AD retinal microvasculature. We speculate that this may be at least in part due to the smaller size of our male AD sample.

Likewise, we have previously shown that TCA and LA are significantly greater in patients with AD.[25] Other studies investigating TCA, LA, and CVI changes in vascular diseases have not explored sex-based differences;[26,27] however, given the finding by Agrawal et al[19] that CVI is

less susceptible to physiologic changes, it is plausible that choroidal vascular changes as measured by TCA and LA are not prone to sex-based physiologic differences. As such, our findings of no significant difference in TCA, LA, or CVI between male and female patients with AD, and their control counterparts are in line with the available literature. Additionally, studies have shown the neuroprotective effects of estrogen in other diseases such as diabetic retinopathy.[28,29] However, given the age group in this study, it is likely that this neuroprotective effect is no longer present, explaining our findings of no sex-based differences. Nonetheless, further studies on choroidal structural change in men and women with AD are needed.

We also demonstrated that cognitively normal men have a thicker CST than women, which has been previously established.[30,31] In the AD group, this sex-based difference in CST thickness was not observed. Because of the cross-sectional nature of our study, we are unable to analyze progression of CST thinning in AD eyes. It is well recognized that CST is thinner in patients with AD compared with cognitively normal controls;[32,33] however, the velocity of change in CST from baseline in men versus women has not been explored. Additional investigation is needed to further assess whether male AD patients exhibit a greater

Table 1. Patient Demographics

	Female AD Participants (n = 41)	Male AD Participants (n = 18)	Female Controls (n = 53)	Male Controls (n = 27)
Age (y) — mean (SD); median (range)	73.0 (7.53); 74.4 (51.1−86)	74.3 (8.2); 74.0 (58.1−86.8)	71.3 (8.69); 71.1 (51−91.1)	72.0 (7.0); 72.7 (53.5−82.7)
Race, No. (%)				
White	38 (92.6)	14 (77.7)	51 (96.2)	26 (96.3)
Black	2 (4.8)	0	0	0
Unreported	1 (2.4)	4 (22.2)	2 (3.7)	1 (3.7)
MMSE score — mean (SD)	21 (4.9)	22.7 (4.4)	29.1 (1.3)	28.6 (1.5)

AD = Alzheimer's disease; MMSE = Mini Mental Status Exam; No. = number; SD = standard deviation; y = years.

Table 2. Comparison of Perfusion and Vessel Densities for 3- and 6-mm ETDRS Circle and Ring Regions in Age-Matched Male and Female Participants with Alzheimer's Disease and Cognitively Normal Controls by Generalized Estimating Equation Multivariate Analysis

OCTA Parameter	Female AD Participants	Male AD Participants	Female Controls	Male Controls	Female vs. Male AD Participants	Female vs. Male Controls	Female AD Participants vs. Female Controls	Male AD Participants vs. Male Controls
PD, mean (SD)								
3-mm circle	0.34 (0.04)	0.33 (0.05)	0.36 (0.03)	0.35 (0.07)	$P = 0.57$	$P = 0.22$	**$P = 0.009$**	$P = 0.52$
3-mm ring	0.36 (0.04)	0.35 (0.05)	0.38 (0.03)	0.36 (0.07)	$P = 0.47$	$P = 0.14$	**$P = 0.005$**	$P = 0.55$
6-mm circle	0.43 (0.03)	0.40 (0.06)	0.44 (0.03)	0.42 (0.08)	$P = 0.09$	$P = 0.38$	$P = 0.12$	$P = 0.38$
6-mm inner ring	0.42 (0.05)	0.40 (0.07)	0.42 (0.05)	0.42 (0.08)	$P = 0.15$	$P = 0.60$	$P = 0.44$	$P = 0.43$
6-mm outer ring	0.44 (0.03)	0.41 (0.06)	0.45 (0.04)	0.43 (0.09)	$P = 0.07$	$P = 0.34$	$P = 0.09$	$P = 0.39$
VD (/mm), mean (SD)								
3-mm circle	18.92 (2.54)	18.51 (2.92)	19.94 (1.79)	19.51 (1.58)	$P = 0.58$	$P = 0.28$	**$P = 0.01$**	$P = 0.08$
3-mm ring	19.9 (2.52)	19.45 (3.05)	20.4 (1.57)	21.1 (1.68)	$P = 0.47$	$P = 0.09$	**$P = 0.008$**	$P = 0.08$
6-mm circle	17.4 (1.34)	16.6 (2.42)	17.7 (1.44)	17.7 (1.35)	$P = 0.11$	$P = 0.98$	$P = 0.21$	**$P = 0.04$**
6-mm inner ring	17.5 (1.85)	16.6 (2.73)	17.8 (1.61)	17.7 (1.70)	$P = 0.16$	$P = 0.97$	$P = 0.35$	$P = 0.050$
6-mm outer ring	17.5 (1.26)	16.9 (2.40)	18.1 (1.40)	17.9 (1.40)	$P = 0.11$	$P = 0.53$	$P = 0.07$	$P = 0.054$

AD = Alzheimer's disease; ETDRS = Early Treatment Diabetic Retinopathy Study; OCTA = OCT angiography; PD = perfusion density; SD = standard deviation; VD = vessel density.

Table 3. A Comparison of OCT and OCTA Parameters between Age-Matched Male and Female Participants with Alzheimer's Disease and Cognitively Normal Controls

OCT and OCTA Parameters	Female AD Participants	Male AD Participant	Female Controls	Male Controls	Female vs. Male AD Participants	Female vs. Male Controls	Female AD Participants vs. Female Controls	Male AD Participants vs. Male Controls
CST (μm), mean (SD)	258.2 (19.9)	261.5 (59.4)	259.8 (25.0)	282.8 (26.9)	$P = 0.81$	**$P < 0.001$**	$P = 0.35$	$P = 0.11$
FAZ area (mm^2)	0.24 (0.1)	0.22 (0.07)	0.28 (0.14)	0.19 (0.10)	$P = 0.24$	**$P = 0.003$**	$P = 0.32$	$P = 0.27$
Global RNFL thickness (μm), mean (SD)	86.2 (9.6)	86.4 (9.9)	91.1 (13.0)	87.8 (9.4)	$P = 0.89$	$P = 0.22$	**$P = 0.04$**	$P = 0.67$
GCIPL thickness (μm), mean (SD)	72.8 (8.1)	67.9 (2.5)	76.9 (6.8)	75.8 (8.6)	$P = 0.054$	$P = 0.43$	**$P = 0.002$**	**$P = 0.001$**
TCA, ($units^2$), mean (SD)	14.7 (5.63)	13.3 (3.52)	13.3 (3.35)	12.3 (2.66)	$P = 0.200$	$P = 0.118$	$P = 0.122$	$P = 0.207$
LA, ($units^2$), mean (SD)	9.37 (3.42)	8.42 (2.12)	8.45 (2.06)	7.82 (1.64)	$P = 0.173$	$P = 0.122$	$P = 0.112$	$P = 0.217$
CVI, mean (SD)	0.639 (0.016)	0.637 (0.014)	0.637 (0.106)	0.639 (0.010)	$P = 0.381$	$P = 0.568$	$P = 0.452$	$P = 0.561$

AD = Alzheimer's disease; CST = central subfield thickness; CVI = choroidal vascularity index; FAZ = foveal avascular zone; GCIPL = ganglion cell-inner plexiform layer; LA = luminal area; OCTA = OCT angiography; RNFL = retinal nerve fiber layer; SD = standard deviation; TCA = total choroidal area. One square unit = 96 × 96 square pixels.

and potentially more rapid decrease in CST compared with female AD patients to account for the loss of sex difference in CST thickness between cognitively normal eyes and AD eyes.

Currently, there is no consensus on the effect of sex differences on the FAZ area in healthy persons.[34,35] We observed a larger FAZ in cognitively normal women compared with their male counterparts, which corroborated the findings by Ghassemi et al.[34] We speculate that this finding is related to the thinner fovea in women.[36] We did not find that VD or PD was significantly different between male and female controls. This is in line with prior findings by Yu et al,[37] who also demonstrated an enlarged FAZ area in female subjects but no sex difference in macular VD or PD. In their study, men had a significantly larger rate of reduction in parafoveal VD as they aged. As such, future longitudinal studies are needed to further understand the relationship among patient sex, FAZ area, and VD.

Average RNFL thickness and GCIPL thickness are reduced in patients with AD.[3,7,9,32,33,38] Some studies examining retinal thickness in patients with cognitive impairment and AD have adjusted for sex or sex matched their participants; however, no studies have specifically evaluated sex differences in RNFL or GCIPL thickness in patients with AD.[3,32] In the present study, we found no significant difference in RNFL thickness in male versus female AD patients. Although AD men showed a trend toward thinner GCIPL thickness compared with women, these findings did not reach statistical significance. It has been shown that neuronal degeneration in the brain is closely related to microvascular changes seen in AD,[20,22,39,40] which may explain our findings of no significant sex differences in either the retinal layers or microvasculature. Given the known sex differences in the incidence and clinical course of AD, our cross-sectional findings that demonstrate no significant sex differences in either the retinal microvasculature or neuronal layers suggest that further study is needed to assess these changes longitudinally to evaluate if there is a difference in the velocity of changes among men compared to women.

Study Limitations

Unique to our study, we investigated patient sex differences in the retinal microvasculature on OCTA in patients with AD.[13-15,41,42] We acknowledge several limitations. First, this study's case-control design limits assessment of progression as well as drawing any causal or temporal conclusions. Second, we did not include positron emission tomography or CSF biomarkers for diagnosis of AD because these tests are not part of routine assessments at our institution. Third, our AD male group was relatively smaller, due in part to strict criteria for image quality, thus limiting the power of our statistical analysis in this group. Finally, because we excluded patients with known confounders such as diabetes, uncontrolled hypertension, diagnosed or suspected glaucoma, age-related macular degeneration, and other vitreoretinal diseases, our findings may not be generalizable to those with those comorbidities.

In conclusion, we demonstrated no differences between male and female AD patients in SCP VD and PD in 3-mm and 6-mm OCTA scans, FAZ area, RNFL thickness, GCIPL thickness, and CVI. These findings are incongruous with observed differences in the incidence and clinical course of AD between men and women. These retinal and choroidal imaging findings raise the possibility that such imaging endpoints might be sex agnostic in AD. A larger, more diverse longitudinal study may provide more insight on the relationship of patient sex to the retinal microvasculature, neuronal layers, and choroidal structure in AD.

Footnotes and Disclosures

[1] iMIND Research Group, Duke University School of Medicine, Durham, North Carolina.

[2] Duke Department of Ophthalmology, Durham, North Carolina.

[3] National Healthcare Group Eye Institute, Tan Tock Seng Hospital, Singapore.

[4] Duke Department of Neurology, Durham, North Carolina.

*D.S.G. and S.F. share senior authorship.

Correspondence:
Sharon Fekrat, MD, Duke University Department of Ophthalmology, 2351 Erwin Road, Box 3802, Durham, NC 27710. . E-mail: Sharon.fekrat@duke.edu.

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