OCT-Angiography Face Mask–Associated Artifacts During the COVID-19 Pandemic

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Précis: Face mask wearing has no significant effects on artifacts or vessel density measurements in optic nerve head (ONH) and macular optical coherence tomography-angiography (OCT-A) scans.

Purpose: The aim was to assess the difference in area of artifacts observed in optical OCT-A scans with and without face mask wear and to verify if mask wear interferes with OCT-A vessel density measurements.

Subjects and Controls: A total of 64 eyes of 10 healthy subjects, 4 ocular hypertensive, 8 glaucoma suspects, and 17 glaucoma patients were included.

Materials and Methods: High-density ONH and macula OCT-A scans were obtained in patients with and without surgical masks. Seven different artifacts (motion, decentration, defocus, shadow, segmentation failure, blink, and Z-offset) were quantitatively evaluated by 2 trained graders. The changes in the area (% of scan area) of artifacts, without and with mask wearing, and differences of vessel density were evaluated.

Results: Trends of increasing motion artifact area for the ONH scans [4.23 (−0.52, 8.98) %, $P = 0.08$] and defocus artifact area for the macular scans [1.06 (−0.14, 2.26) %, $P = 0.08$] were found with face mask wear. However, there were no significant differences in the mean % area of any artifacts ($P > 0.05$ for all). Further, the estimated mean difference in vessel density in images acquired without and with masks was not significant for any type of artifact.

Conclusion: Face mask wearing had no significant effect on area of artifacts or vessel density measurements. OCT-A vessel density measurements can be acquired reliably with face mask wear during the pandemic.

Received for publication November 4, 2021; accepted March 10, 2022.
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National Institutes of Health/National Eye Institute Grants EY11008, EY19869, EY14267, EY027510, EY026574, EY027945, EY029058, P30EY022589, Unrestricted grant from Research to Prevent Blindness, New York, New York.
Disclosure: N.W.E.-N.: current employment at Topcon Healthcare, but all work related to the current manuscript was done before employment. L.M.Z.: F: National Eye Institute, Carl Zeiss Meditec Inc., Heidelberg Engineering GmbH, Optovue Inc., Topcon Medical Systems Inc. R.N.W.: F: National Eye Institute, Heidelberg Engineering, Carl Zeiss Meditec, Konan, Optovue, Topcon, Centervue. C: Aerie Pharmaceuticals, Alcon, Allergan, Bausch & Lomb, Equinox, Eyenovia. The remaining authors declare no conflict of interest.
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DOI: 10.1097/IJG.0000000000002019

Key Words: optical coherence tomography-angiography, artifacts, face mask, pandemic, imaging, glaucoma, vessel density

(*J Glaucoma* 2022;31:399–405)

The coronavirus disease-2019 (COVID-19) pandemic has dramatically impacted health care standards in clinical practice. Social distancing and the use of personal protective face masks remain standard procedure in hospitals and clinics even after receiving the COVID-19 vaccination. This safety practice may continue for years in many locations around the world. Ophthalmic care now typically employs these procedures to reduce viral transmission.[1]

Several reports have documented that fogging and improper face mask fit are particularly challenging during visual field (VF) testing, and lead to unreliable VF tests and artifacts.[2–5] To the best of our knowledge, the effect of face masks on test reliability and induced artifacts in ocular imaging has not been reported.

Optical coherence tomography-angiography (OCT-A) is a noninvasive, high-resolution, 3-dimentional imaging modality used to qualitatively and quantitatively assess the retinal microvasculature, including the optic nerve head (ONH) and macula.[6–9] Specifically, OCT-A has been used to measure vessel density, which is defined as the % area occupied by blood flow in retinal vessels. OCT-A does appear to be a promising tool in glaucoma care, especially in improving early diagnosis, predicting progression, and evaluating end-stages of the disease.[9–13]

Different types of artifacts in OCT-A imaging, such as decentration, eye motion, segmentation error, defocus, shadow, blink, and Z-offset, have been described and determined to influence the reliability and repeatability of the various OCT-A scan measurements.[14–18]

The purposes of this study were to assess the difference in area, defined as the percent of scan area occupied by the artifact, of seven different types of OCT-A artifacts in healthy, ocular hypertension, glaucoma suspect, and glaucoma patients without and with face mask wear and to verify if mask wear interferes with OCT-A vessel density measurements.

MATERIALS AND METHODS

Participants enrolled in the longitudinal Diagnostics Innovations in Glaucoma Study (DIGS)[19,20] or directly referred from the Shiley Eye Institute glaucoma clinic at the University of California San Diego, who underwent OCT-A (Angiovue; Optovue Inc., Fremont, CA) imaging without and with face mask wearing were included in this study.

Each participant wore the same type of surgical ear-loop disposable face mask (Grainger, Model # 56JD44), which they received upon entry to the study building. The research protocol adhered to the tenets of the Declaration of Helsinki and was approved by the University of California, San Diego Institutional Review Board. All study participants signed an informed consent form.

Participants

Eligible participants were older than 18 years of age, with best-corrected visual acuity of 20/40 or better and open angles based on gonioscopy at study entry. Each of them underwent a comprehensive ophthalmic examination, including best-corrected visual acuity, slit-lamp biomicroscopy, intraocular pressure (IOP) using Goldmann applanation tonometry, pachymetry, dilated fundus examination, stereophotography of the optic disc and macula, and VF testing. In addition, participants had spectral domain OCT and OCT-A imaging. Patients with a history of ocular trauma or intraocular surgeries (except for uncomplicated cataract and uncomplicated glaucoma procedures), non-glaucomatous optic neuropathy, coexisting retinal diseases, or ocular inflammation were excluded from this study.

Eyes of participants were divided into 4 diagnostic groups: healthy, ocular hypertension, glaucoma suspect, and glaucoma. Healthy eyes had IOP $\leq$21 mm Hg, normal-appearing optic discs and neuroretinal rims, and normal VF test results defined as pattern standard deviation (PSD) within the 95% confidence limits and Glaucoma Hemifield Test (GHT) results within normal limits, with the Humphrey Field Analyzer SITA standard 24-2 (Carl Zeiss Meditec, Dublin, CA) Swedish Interactive Thresholding Algorithm. Ocular hypertensive eyes had IOP $>$21 mm Hg, normal-appearing optic discs, and normal VF test results. The glaucoma suspect group included eyes with glaucomatous optic neuropathy or suspicious appearing optic nerves based on the review of stereoscopic photographs of the ONH, with or without elevated IOP ($>$21 mm Hg), without evidence of repeatable glaucomatous VF damage. Eyes were categorized as glaucomatous if they had at least 2 reliable ($\leq$33% fixation losses, false-negatives, and false-positives) and repeatable abnormal VF results (GHT outside normal limits or PSD outside 95% normal limits) with similar glaucomatous defect patterns on consecutive testing as evaluated by study investigators.

OCT-A Imaging Acquisition

OCT-A is a noninvasive, 3-dimensonal imaging modality that enables retinal microvasculature visualization using the dynamic motion of red blood cells.[6–9]

The Avanti AngioVue (OptoVue Inc., Fremont, CA; software version 2018.1.0.43) was utilized. High-density (HD) ONH and macula OCT-A scans were acquired. The HD scans consisted of merged Fast-X volume of 400 horizontal B-scans of 400 A-scans per B-scan and Fast-Y volume of 400 vertical B-scans of 400 A-scans per B-scan. Macular scans were obtained over 6×6 mm^2 cross-sectional areas with the fovea being in the center. The ONH scans were centered over an area of 4.5×4.5 mm^2.

Various artifacts and vessel density measurements were compared in the same scan type of the same participant before and after March 16,2020. This was the date at which mask wearing became compulsory in our clinic. There was a maximum of 1 year difference between scans captured without and with face mask wearing. Considering the importance of superficial capillary plexus (SCP) layer in glaucoma diagnosis and progression,[21–24] the presence of artifacts and vessel density measurements were evaluated in the SCP layer only. The macular SCP was measured from the internal limiting membrane to 10 μm below the inner plexiform layer. The ONH SCP extended from the internal limiting membrane to the retinal nerve fiber layer posterior boundary.

Types of Artifacts

Different types of OCT-A image artifacts, including motion, decentration, defocus, shadow, segmentation failure, blink, and Z-offset have been evaluated and described in previous studies.[14–18] In this study, 7 types of artifacts (Table 1 and Fig. 1) were quantitatively evaluated through outlining the affected en-face area of the artifact using Adobe Photoshop (Version 9.0). In brief, all OCT-A scans were exported by the RTVue software and saved as PNG files. The images were analyzed in random order. The areas of motion and blink artifacts were outlined with rectangles (Fig. 2A), while the areas of defocus and shadow artifacts were delineated by indicating the exact position of each artifact's border (Fig. 2B). Decentration in the horizontal and vertical directions was measured from the center of each scan, which was defined as the crossing of the 200th vertical (Fig. 2C green line) and horizontal (Fig. 2C red line) B-scans. Segmentation error and Z-offset required a careful evaluation of the consecutive B-scans using the OCT-A software. The specific artifact areas were also outlined with rectangles. Two trained graders (N.W.E.-N. and E.M.), masked to patient diagnosis and date, quantitatively outlined the various artifacts. The area of the artifact was automatically calculated after it was outlined using the selection tools in Photoshop. The area of the artifact was then divided by the total scan area of 160,000 pixels. The average area

TABLE 1. Descriptions of 7 Types of Artifacts Seen in OCT-Angiography Scans

Artifact	Description
A. Motion	Vertical or horizontal fine white lines leading to disruption, dislocation, or doubling of the blood vessels
B. Decentration	Translocation of the optic nerve head or macular center to the periphery of en-face scan
C. Defocus	Decreased clear definition and visualization of blood vessels details
D. Shadow	Decreased retinal intensity in a specific area mainly because of vitreous floaters or corneal opacities
E. Segmentation	Deviation of the total B-scan thickness because of incorrect identification of the borders of retinal layers by the automated segmentation algorithm
F. Z-offset	Loss of B-scans peripheral borders outside the en-face scan
G. Blink	Complete signal void (black) because of blink during the image capture

OCT indicates optical coherence tomography.

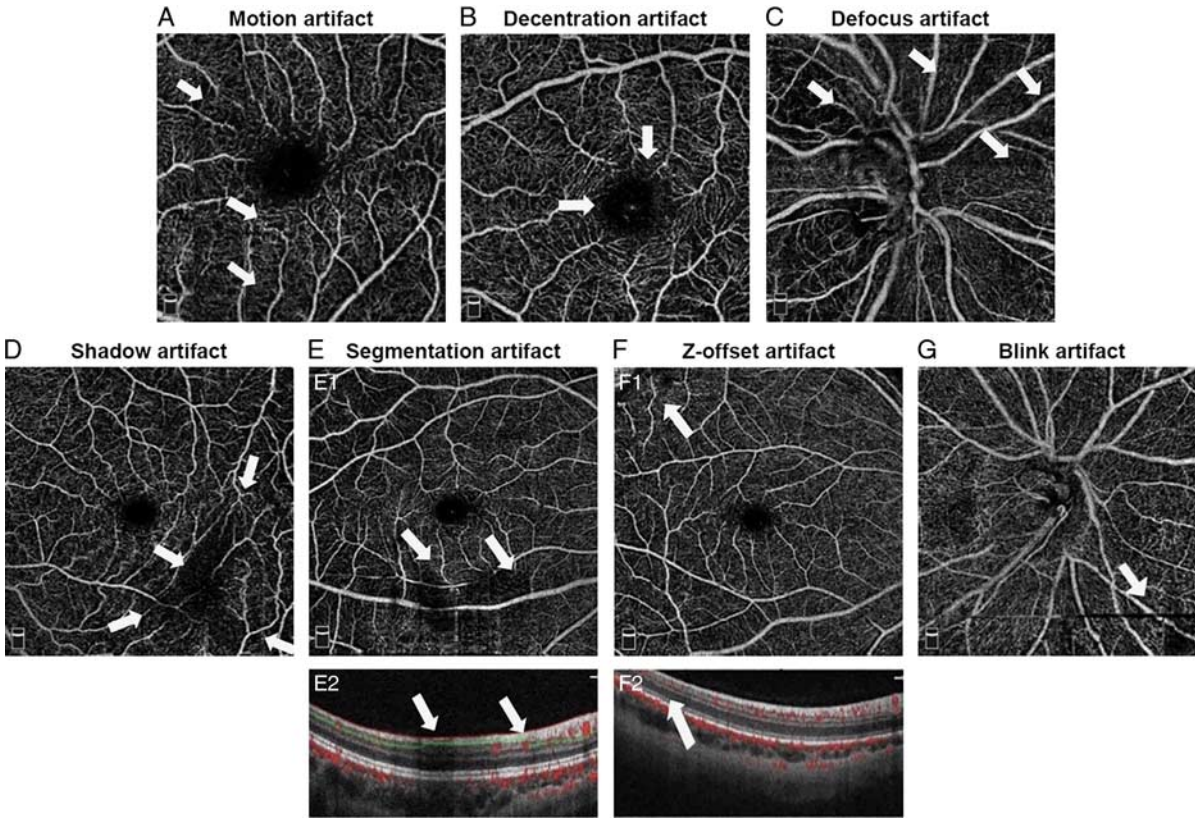

FIGURE 1. Types of artifacts seen in optical coherence tomography-angiography scans. A, Motion (white arrows show the vertical and horizontal fine lines leading to disruptions of the microvasculature patterns). B, Decentration (arrows show the translocation of the macular center to the periphery of the scan). C, Defocus (arrows show decreased visualization of blood vessels details). D, Shadow (arrows show the area of decreased retinal intensity because of vitreous floater. E, Segmentation error (E1 shows en-face image with segmentation error, E2 shows deviation of the B-scan thickness because of incorrect identification of the retinal borders by the automated segmentation algorithm) (arrows shows segmentation failure due to incorrect identification of the borders of retinal layers). F, Z-offset (F1 shows loss of B-scans peripheral borders outside the scan, F2 shows en-face image with Z-offset) (arrows shows cropping due to loss of B-scan borders outside the scan). G, Blink [arrow shows the complete signal void (black) horizontal line]. Figure 1 can be viewed in color online at www.glaucomajournal.com.

from the 2 investigators were used in the analysis. A third investigator (T.N.) adjudicated and measured the artifacts in case of disagreement (difference $>10\%$ of the scan area measured). In this study, severe artifacts were defined as those with an area $>10\%$ of the total scan area ($>16{,}000$ pixels).

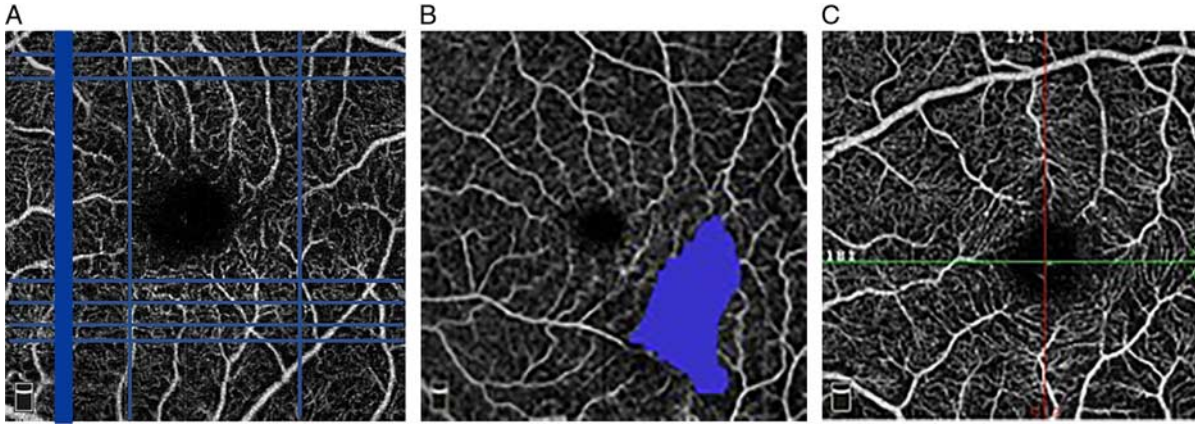

FIGURE 2. Representative examples of (A) Eye motion quantified (sum of all blue outlined areas) using Photoshop (similar method was performed to measure the area of blink artifact). B, Shadow quantified (entire blue area) using Photoshop (same for defocus). C, Decentration measurement using the vertical and horizontal B-scans. Figure 2 can be viewed in color online at www.glaucomajournal.com.

TABLE 2. Patient Demographic and Clinical Characteristics

Demographic	n = 64 eyes of 35 patients
Mean age, years [range]	66.3 [28.9, 82.6]
Sex (female/male)	20/15
Race (African American/non-African American)	8/27
Systemic characteristics	
Self-reported hypertension, n (%)	15 (42.9)
Self-reported diabetes, n (%)	4 (11.4)
Ophthalmic characteristics	
Healthy, eye no. (%)	17 (27.0)
OHT, eye no. (%)	4 (6.4)
Glaucoma suspects, eye no. (%)	11 (17.5)
POAG, eye no. (%)	29 (46.0)
Axial length (mm)	25.6 (22.7, 28.6)
CCT (μm)	551.8 (438.3, 604.0)
Baseline IOP (mm Hg)	14.4 (4.0, 30.0)
Baseline VF MD (dB)	−9.6 (−20.2, 1.6)
Baseline VF PSD (dB)	7.9 (1.3, 14.4)

CCT indicates central corneal thickness; IOP, intraocular pressure; OHT, ocular hypertension; POAG, primary open angle glaucoma; PSD, pattern standard deviation; VF, visual field.

Statistical Analysis

Patient and eye characteristics were presented as mean [95% confidence interval (CI)] for continuous data and count (percentage) for categorical data.

Differences (±CI) in percentage average area of nonsevere and severe artifacts in HD ONH and macular OCT-A scans before and after face mask wear were compared using paired, clustered t test to account for random effect intereye correlation. Evaluation of the effect of the difference of artifacts area on the vessel density changes without and with face mask wear was performed using a linear mixed model with random intercepts and random slopes. P-values <0.05 were considered statistically significant. All statistical analyses were performed using the R statistical software (version 3.6.3) and STATA (version 16.0).

RESULTS

A total of 254 HD OCT-A scans from 35 patients (64 eyes) diagnosed as ocular hypertension (n = 4, 6.4%), glaucoma suspect (n = 11, 17.5%), and primary open angle glaucoma (n = 29, 46.0%), as well as healthy eyes (n = 17, 27.0%) were included in this study. Demographic data, systemic, and ophthalmic characteristics of all patients are described in Table 2. The mean difference (95% CI) in visit time between scans captured without and with face mask wearing was 0.31 (0.25, 0.37) years. HD images with a minimum artifact area >10% of the total scan area (>16,000 pixels; severe artifacts) were mainly included in the statistical analysis. Eye motion artifact was the most prevalent type of severe artifact detected in the ONH OCT-A scans (39.0%), followed by Z-offset (7.0%), segmentation errors (6.0%), and defocus (4.0%). For macular OCT-A scans, the prevalence of motion artifact was still the highest (50.0%), followed by segmentation errors (12.5%), defocus (8.0%), and Z-offset (6.0%) (Table 3) without mask wear. The prevalence of blink, shadow, and decentration was very low (≤1.0%; data not shown).

TABLE 3. The Prevalence (% of Eyes With Artifact) of Severe Motion, Defocus, Segmentation, and Z-offset Artifacts Without Mask Wear

Artifact Type	Optic Nerve Head (%)	Macula (%)
Motion	39.0	50.0
Defocus	4.0	8.0
Segmentation	6.0	12.5
Z-offset	7.0	6.0

Table 4 shows the difference in % average area of 7 artifact types from HD ONH and macular scans with mask wear compared with without face mask wear. Although there was a trend of increased motion artifact area with face mask wear for the ONH scans [4.23 (−0.52, 8.98) %, $P = 0.08$] and a similar trend of defocus artifact area for the macular scans [1.06 (−0.14, 2.26) %, $P = 0.08$], none of the differences in the average area of any artifacts reached statistical significance ($P > 0.05$ for all). Table 4 compares the difference in % average area of severe artifacts in HD ONH (n = 64 eyes) and macular scans (n = 64 eyes) with and without face mask wear. Likewise, none of the differences because of mask wear in the average area of severe motion, defocus, segmentation, and Z-offset artifacts were statistically significant.

Table 5 summarizes the number of eyes that had ONH and macular scans with the presence or absence of artifacts with and without face mask wear. Most of the eyes that had ONH and macular scans with motion, defocus, and Z-offset artifacts without mask wear, also had these artifacts with mask wear. For example, 62 of 64 eyes with ONH scans and 61 of 64 eyes with macular scans had motion artifacts before and after face mask wear. For the ONH scans, the majority of eyes with no blink, shadow, or segmentation artifacts without mask wear did not have these artifacts with mask wear. A small number of eyes (≤15) with either scan type had no artifacts without mask wear, but had artifacts with mask wear. With the exception of blink and shadow artifacts, ≤8 eyes with either scan type had artifacts without mask wear that were not detectable with mask wear.

The estimate difference in vessel density based on the difference of the average percentage area of artifacts without and with face mask wear was very small for all artifacts and did not reach statistical significance for ONH and macula motion, blink, shadow, and decentration artifacts (Table 6). For the ONH scans, the estimated mean difference in vessel density in images acquired without and with masks for segmentation and Z-offset artifacts were statistically significant, but extremely small (basically 0) (–0.00007%; $P < 0.001$) and (0.00008%; $P = 0.029$), respectively. For the macular scans, the estimated mean difference in vessel density in images acquired without and with masks for defocus artifact was also ~0 (−0.0001%; $P = 0.011$). The global differences (95% CI) in the ONH and macular vessel density measurements with and without mask wear, regardless of the presence of artifacts, were −0.33 (−0.99, 0.32) % and −0.73 (−1.96, 0.50) %, respectively.

The difference (95% CI) in signal strength index, which is a measure of overall quality, before and after face mask wear was −1.00 (−3.95,1.94); $P = 0.497$ for ONH scans and −0.99 (−2.67, 0.68); $P = 0.242$ for macular scans.

The estimates of mean deviation (MD), PSD, and age with the average areas of artifacts in both types of scans before mask wear were calculated. No association was found between artifact area without face mask wear and glaucoma severity (VF MD or PSD) or age (data not shown; $P > 0.05$ for all).

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TABLE 4. Difference (±95% CI) in Average Area (%) of All (Nonsevere and Severe) artifacts and Difference (±95% CI) in Average Area (%) of Severe Artifacts in High-Density Optic Nerve Head and Macular OCT-Angiography Scans With Compared to Without Face Mask Wear

	Optic Nerve Head			Macula		
Artifact Type	**Difference (%)**	**95% CI**	***P***	**Difference (%)**	**95% CI**	***P***
All artifacts						
Motion	4.23	−0.52, 8.98	0.08	2.00	−1.07, 5.07	0.20
Blink	0.08	−0.14, 0.29	0.48	0.008	−0.07, 0.09	0.84
Defocus	0.22	−0.25, 0.69	0.35	1.06	−0.14, 2.26	0.08
Shadow	0.13	−0.08, 0.34	0.23	−0.006	−0.21, 0.20	0.96
Decentration	0.00	−0.003, 0.001	0.53	0.0006	−0.0008, 0.002	0.39
Segmentation	0.43	−1.87, 2.74	0.71	0.87	−0.60, 2.34	0.24
Z-offset	−0.77	−1.98, 0.45	0.21	0.83	−0.37, 2.02	0.17
Severe artifacts						
Motion	−4.9	−13.45, 3.63	0.25	−3.29	−15.30, 8.73	0.58
Defocus	2.48	−5.58, 10.55	0.32	−2.82	−14.12, 8.49	0.53
Segmentation	0.43	−1.87, 2.74	0.71	0.87	−0.60, 2.34	0.24
Z-offset	−8.84	−26.31, 8.63	0.23	0.32	−4.49, 5.13	0.85

CI indicates confidence interval; OCT, optical coherence tomography.

DISCUSSION

Our results suggested that there were no significant differences in any of the artifact areas with face mask wear. Moreover, mask wear had no clinically significant effect on ONH or macular vessel density measurements.

The presence of different types of artifacts leads to poor image quality and can affect the validity and repeatability of OCT-A measures. To date, previous OCT-A studies have qualitatively evaluated the prevalence of artifacts.[14,16,17] The prevalence of severe OCT-A artifacts was inconsistent in these studies. For instance, Holmen et al[14] graded each artifact based on a severity scale (0 to 3) and reported a high overall prevalence of severe artifacts (50%) in macular OCT-A scans in diabetic patients. In contrast, a study by Enders et al[16] found a much lower prevalence of severe artifacts (9%) in patients with various retinal conditions. More recently, Kamalipour et al[17] evaluated a total of 5263 ONH and macular OCT-A scans of healthy, glaucoma suspect, and glaucoma patients and reported the prevalence of severe artifacts to be about 30%. The observed inconsistency in the prevalence of artifacts across studies, may be because of the differences in the definition of artifact's types and severity among different studies. Further, the differences in operators' expertise in capturing OCT-A scans may lead to longer image acquisition time resulting in increased artifacts (ie, motion) and poor subject cooperation. The OCT-A instrument used and the imaging software version along with artifact detection algorithms may also in part account for these inconsistencies. Furthermore, artifacts may occur more frequently in eyes with various ocular pathologies than in healthy eyes.[25] For instance, ONH and retinal pathologies may change the structures needed as a reference for segmentation leading to the emergence of artifacts, especially segmentation errors. In contrast to previous studies, OCT-A artifacts were evaluated quantitatively in the present study. Thus, the overall prevalence of severe artifacts was

TABLE 5. 2×2 Tables Demonstrating the Number of Eyes Having High-Density Optic Nerve Head and Macular Scans With or Without Various Types of Artifacts Without and With Face Mask Wear

	ONH		Macula	
	Artifact−	**Artifact+**	**Artifact−**	**Artifact+**
Motion		Without Mask		
With mask				
Artifact−	0	1	0	1
Artifact+	1	62	2	61
Blink		Without mask		
With mask				
Artifact−	37	8	3	11
Artifact+	7	11	2	48
Defocus		Without mask		
With mask				
Artifact−	29	0	10	6
Artifact+	0	34	15	33
Shadow		Without mask		
With mask				
Artifact−	37	4	26	10
Artifact+	11	11	11	17
Segmentation		Without mask		
With mask				
Artifact−	42	7	15	8
Artifact+	2	12	9	32
Z-offset		Without mask		
With mask				
Artifact−	10	7	1	1
Artifact+	4	42	0	62

ONH indicates optic nerve head.

TABLE 6. Estimation of Difference in Vessel Density With and Without Face Mask Wear Based on the Difference of Average Percentage Area of Each Artifact

	Optic Nerve Head		Macula	
Artifact	**Estimate (%)**	***P***	**Estimate (%)**	***P***
Motion	0.000001	0.867	0.00001	0.175
Blink	–0.0002	0.248	0.0001	0.758
Defocus	0.00006	0.599	–0.0001	0.011
Shadow	–0.0001	0.469	0.00001	0.957
Decentration	0.008	0.729	0.02	0.501
Segmentation	–0.00007	< 0.001	0.00001	0.799
Z-offset	0.00008	0.029	0.00003	0.542

relatively high (ONH: 43.0%, macula: 56.0%) compared with most previous studies. In this study, artifacts were evaluated quantitatively to establish a more objective, focused, repeatable, and less biased method of measuring areas of artifacts. It might be plausible to experience more eye movement while wearing a protective mask possibly because of mask-induced dry ocular surface that may cause eye irritation and increased blinking.[26] In addition, fogging of the OCT-A lens, induced by the exhaled breath from the top of the mask because of improper face mask fit, may lead to more eye and head movements to focus on the OCT-A inner target. Accurate head placement may also increase defocus artifacts.[14,27] Further, fogging may affect the clarity of the images because of alteration in the illumination. In the current study, there was a trend of increasing motion artifact area for ONH scans and defocus artifact area for macular scans acquired with mask wear, however, these differences were not significant. In general, to prevent exhaled air from fogging the OCT-A lens and/or induce dryness and irritation to patients' eyes, it is recommended the face mask be taped to the patients' nose-bridge,[28] use dual face masks,[29] or wear a tie-back surgical face mask.[30] The tie-back method is described as knotting the top mask tie below the ears and the bottom tie above the crown of the head and in front of the ears. This method allows a tighter seal over the nose, prevents superior air leakage, and creates 2 side vents. Thus, the described method might minimize fogging because of allowing exhaled air to escape away from patients eyes and therefore, reduce any OCT-A artifacts.[30]

As alluded to earlier, several studies have shown that fogging may result in unreliable VF testing and induced glaucoma-like artifacts because of obstructing patients' vision, which leads to inconsistent VF responses.[2–5] Alternatively, fogging may not increase the area of artifacts nor affect vessel density measurements in OCT-A imaging. This is probably because of differences with each technique; VF is a subjective measure of central and peripheral vision, whereas OCT-A is an objective measure of vessel density and does not depend on patients' responses. Previous studies have demonstrated that individual demographics and ocular characteristics are correlated with the possibility of capturing good quality OCT-A scans with minimal artifacts.[14,15,17,25] For instance, age, sex, and pathologic factors (such as glaucoma severity) were all correlated with the presence of artifacts in these studies. Specifically, there was a higher probability of obtaining poor-quality OCT-A scans with severe artifacts, mainly because of failure in segmentation of the diseased retinal layers, in older patients with age-related pathologies of the ONH and retina.[15,17,25] In the present study, age and glaucoma severity (defined by VF MD and PSD) were not correlated with either the presence of artifacts presence nor the quality of OCT-A images without mask wear. These conflicting results may be because of the different design of the current study with quantitative evaluation of the artifacts.

Study Limitations

Our study has several limitations. First, we have a relatively small sample size, which may limit our ability to detect significant differences. The smaller sample size is because of the limited time difference (maximum of 1 y) that was required between OCT-A scans captured before and after mask wear. This limited our ability to compare artifacts in 1-year apart OCT-A scans of participants not wearing face mask to artifacts in 1-year apart scans of participants wearing face mask to determine if masks create variance higher than routine 1 year variability. Second, unlike previous studies, we found no correlation between artifacts and age or glaucoma severity, possibly because of the unique study methodology and the smaller sample size. Third, vessel density measurements could have changed because of glaucoma progression or changes in ocular hypertensive and glaucoma suspect eyes and not because of presence or increased artifacts after the duration of 1 year. However, there were no clinically significant differences in vessel density in any of the four groups, including healthy controls (data not shown). Fourth, the use of one OCT-A device (ie, Angiovue) may limit extrapolation of results using other OCT-A devices. Fifth, by UC San Diego health care rules, researchers were not allowed to obtain mask-on and mask-off measurements in the same session, because face masks must be always worn in the clinic during the pandemic. Last, we had a relatively higher prevalence of artifacts associated with OCT-A image quality than previously. This could be because of: (1) the artifacts were quantitatively measured, (2) number of artifacts may be influenced by operators' expertise and patients' compliance, and (3) the 2 masked graders adhered to a thorough evaluation and measurement of the artifacts.

In conclusion, protective face mask wearing has no significant effects on artifacts or vessel density measurements in OCT-A acquired scans. Therefore, clinicians and researchers should identify and minimize the other main causes of artifacts, such as operator-related errors, patient-related factors, and/or software errors to avoid clinical misinterpretations and inappropriate investigations. Although detailed review of image artifacts is needed to accurately interpret vessel density measurements, our findings are reassuring for clinicians and researchers, who can dependably use the quantitative vessel density measurements from OCT-A scans acquired with face mask wear.

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