Review Article

Artifacts in Macular Optical Coherence Tomography

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Abstract

Purpose: To identify and explain different artifacts in macular optical coherence tomography (OCT).

Methods: For this comprehensive review, a PubMed and Google Scholar (January 1995–October 2018) search was conducted by the researchers, using the keywords such as OCT, artifacts, artefact, and macula.

Results: We reviewed the main OCT artifacts including software break-down or misidentification of retinal layers, incomplete segmentation error, complete segmentation failure, mirror artifact (inverted artifact), cut edge artifact, degraded image scan, out-of-register artifact, off-center artifact, motion artifact, foveal duplication, segmentation shift, blink artifact, static or fixed image artifact, linear artifact, and perfluorocarbon liquid-producing artifact.

Conclusions: There are various artifacts in OCT image scans. The identification of these artifacts may help in accurate interpretations of OCT images in clinical settings that can affect the diagnosis and management of different retinal disorders.

Keywords: Artefact, Artifacts, Macula, Optical coherence tomography

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Introduction

Optical coherence tomography (OCT) provides depth-resolved non-invasive imaging from retinal layers.[1] Using OCT, much information can be obtained such as automatically measured retinal thickness and parallelism of retinal layers. Detecting the kind of artifacts on OCT images has their effect on the interpretation of the image. OCT artifacts could be patient-, operator-, software-, and hardware-related and also can occur during image acquisition, processing, and/or analysis.[2] Some studies characterized the types and frequencies of image artifacts of macular spectral-domain OCT (SD-OCT) in the evaluation of retinal diseases. As many as 90.9% of scans had at least one artifact,[3] and clinically, significant artifacts were observed in 6–8.0% of scans.[3,4] The prevalence of image artifact in OCT angiography (OCTA) is comparable with structural OCT.[5,6]

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Identifying and understanding the OCT artifacts have clinical importance in the correct interpretation of the observed findings in OCT and OCTA images.[5,7] Misidentification of retinal boundaries occurred frequently in retinal disorders, including vitreoretinal interface disorders and age-related macular degeneration (AMD).[4,7] The misidentification of retinal borders can affect the retinal thickness, which is important in follow-up examination of some retinal disorders such as AMD.

While patient- and operator-related artifacts can, to some extent, be controlled, software-related mistakes are inevitable and are now the most prevalent.[8] Patient-related artifacts are mostly due to eye movements, ocular pathology, and low vision, manageable by eye tracking software and higher speed imaging. Operator-related artifacts include decentered scans, out of registration, cut images, and degraded images owing to poor focus.[8] Software-related artifacts are mostly owing to failed segmentation algorithms, which result in the

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misidentification of inner and/or outer retinal boundaries, and incomplete segmentation artifacts.[8]

In this article, we described the various artifacts that can occur in macular OCT.

Methods

For this comprehensive review, a PubMed and Google Scholar (January 1995–October 2018) search was performed using the keywords such as optical coherence tomography, OCT, artifacts, artefact, and macula. Additional databases such as the Cochrane Library and clinicaltrials.gov were also explored to identify unpublished research.

A selection of articles was taken from the search. A focused search guided by reading the abstract was also done across the references mentioned in those papers. Papers with full text in languages other than English or French were excluded. We included case series and articles explaining a single or different kinds of artifacts. Eventually, 38 references in English were included. A total of 27 papers were obtained from the initial search, and 11 papers were obtained by hand searching from the references of the papers found in the initial search. All of the 38 articles were read in full by the researchers. No contact with authors was made.

Results

Different types of artifacts are summarized in Table 1. The artifacts have been reported by both time-domain OCT (TD-OCT) and SD-OCT, although some artifacts are specific for SD-OCT devices.

Software-related artifacts

Segmentation error

Researchers defined the segmentation error and missing segmentation line as an error in accurate location of the border and absence of segmentation line noted in the boundaries.[24] These artifacts are produced by incorrect detection of borders of the retinal layers [Figure 1a] that are more frequently in TD-OCT as compared with SD-OCT.[4] The existence of misidentification can give rise to thickness map error.[4] Although these errors were seen in healthy retinal imaging, the inner (vitreoretinal interface disorders, including epiretinal membrane, vitreomacular traction, and macular hole) and outer (pigment epithelial detachment, central serous chorioretinopathy, AMD, cystoid macular edema, and geographic atrophy) retinal disorders were frequently reported as the causes of misidentification of retinal boundaries.[4] Probably, due to more prevalence of vitreoretinal interface disorders, misidentification of the inner retina is more frequent than misidentification of the outer retina.[7]

The frequency of these artifacts was different according to the OCT device used. For the detection of retinal thickness in different devices, the distance between inner retinal border and outer retinal border is calculated. All the OCT instruments identify the inner retinal boundary as the first interferometric signal after the vitreous hypo-reflective space, which corresponds to the internal limiting membrane.

The outer bound differs according to the device used. Stratus Zeiss OCT identifies the outer boundary at the inner–outer segment junction of photoreceptor (ellipsoid zone). The Topcon 3D OCT-1000 and the Copernicus OCT identify the inner part of retinal pigment epithelium (RPE) layer as the outer boundary, the Zeiss Cirrus the middle of the RPE, the OptovueRTvue-100 the external outer part of the RPE, and the Heidelberg Spectralis at the Bruch membrane.[7,11,25-30]

Giani *et al*. compared the frequency of inner/outer retinal misidentification in different devices of OCT.[27] They reported that the error frequency was higher in TD-OCT as compared with SD-OCT.[27]

Further classification for segmentation error was introduced by Han *et al*.[3] as the proportion of involvement in the retinal thickness as mild (the segmentation error <1/3 of retinal thickness), moderate (between 1/3 and 2/3 of retinal thickness), and severe (more than 2/3 retinal thickness).[3] The

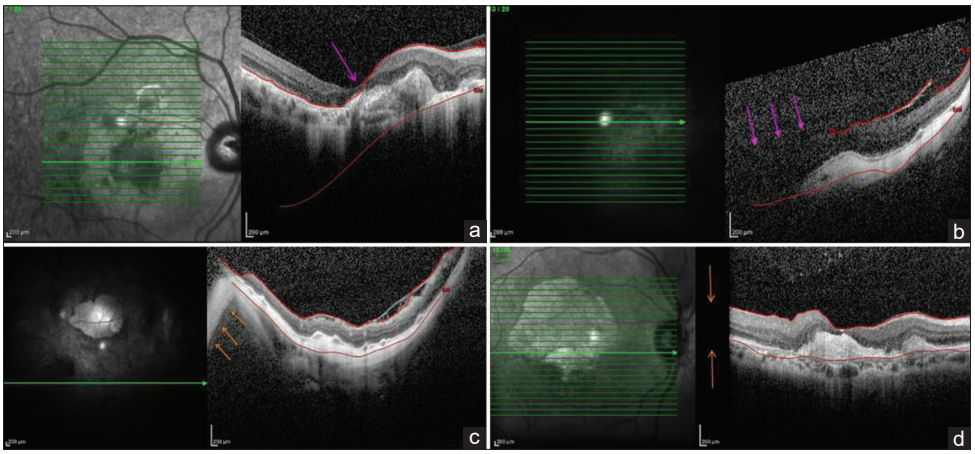

Figure 1: Various artifacts in optical coherence tomography. (a) Misidentification error is observed in the outer and inner retinal boundary (purple arrow). (b) Incomplete segmentation error is shown by purple arrows. (c) Mirror artifact (orange arrows). (d) Cut edge artifact (orange arrows)

Table 1: Different types of artifact in optical coherence tomography

Type of artifacts	Definition	Frequency (%)	Time-domain OCT	Fourier-domain OCT	Patient-related	Operator-related	Software- and hardware-related	What to do?
				Software				
Misidentification of retinal layers[3,4]	Incorrect detection of borders of the retinal layers	?	+	+	+*		+	Manual correction
Incomplete segmentation error[5]	Stop or missing segmentation lines before reaching the lateral sides of scan	33.2	+	+	+*		+	Repeat the scan in the area of interest
Complete segmentation failure[9]	No segmentation lines placed along retina boundaries	2-4.5	+	+	+*	+**	+	Repeat the scan in the area of interest
Mirror artifact (inverted artifact)[10]	Image folds on itself around the zero line, in entire length or at the end (s) of the image	9.3	-	+	+*	+**	+	Repeat the scan in the area of interest
Degraded image scan[11,12]	Apparently look-like broken retina (a type of misidentification)	6.7-11.7	+	+	+&		+	Repeat scan after proper positioning
Static or fixed image artifact[5]	In multiple adjacent B-scans, a fixed part of image with no changes is observed	Rare	-	+			+	Repeat the scan
Linear artifact[13]	Three hyper-reflective lines with the stable location that could be beyond, beneath, or at the identical level of the sclera-choroidal interface in the enhanced depth imaging OCT	81.88	-	+			+	Consider it when the choroidal thickness is more than 485 Repeat the scan Capture images as clearly as possible Evaluate images under the primary mode, that is, a white line on a black background
PFCL-producing artifact[14]	Distortion of structures below bubble of PFCL with		+	+	+*	+	+	
				Operator-related				
Cut edge artifact[11,15,16]	Edge of the scan is inappropriately illustrated	0.17-6.3	+	+	+!	+		Ignore the first scan
Out-of-register artifact[7,11,12]	Vertically displaced image as much as a part of the inner or outer retina is located out of the range of scan	2.4-13	++			+	+	Repeat the scan after realigning the area of interest
				Patient-related				
Blink artifact[12]	A part of data are lost due to patient's blinking	0.09	++	+	+			Repeat the scan
Off-center artifact[7,17-19]	Displacement of fovea over 0.25 mm from its real location	3.7-16.7	+	+	+*			Repeat the scan/manually plot the fovea
Motion artifact[4,17,20,21]	Structural distortion in image due to eye movement		++	+	+		+	Repeat the scan and devices with eye tracking

Contd...

misidentification errors result in incorrect foveal thickness if it occurs in the central 1 mm region of ETDRS and topographic map.[7,31]

Misidentification of the retinal layers can occur in eyes with retinopathy of prematurity.[32] They inferred these findings to fine abnormalities in the external limiting membrane and cone outer segment tips of the outer retina.[32]

The segmentation of ganglion cell layer (GCL) and GCL-inner plexiform layer (GCL-IPL) (area between outer borders of two layers consist of retinal nerve fiber layer and IPL) has a diagnostic value in some macular and optic nerve disorders, including glaucomatous eye and neuroretinal degenerations.[9,33-37] Further classification for segmentation error in GCL-IPL was introduced as mild, moderate, and severe according to the amount of error < 10 μm, between 10 and 50 μm, and > 50 μm.[9] Alshareef *et al*. reported the segmentation errors of macular GCLs with different frequencies in various conditions, including healthy eye (20.79%), retinitis pigmentosa (95.8%), central serous chorioretinopathy (40%), dry- and wet-type AMD (20.5% and 58%), diabetic macular edema (48%), and epiretinal membrane (16%).[9] Overall, they found more artifacts' frequency in eyes with macular disorders (55%) versus healthy macula (26.8%).[9] They suggested that the existence of macular disorders perhaps largely affect the measurement of GCL-IPL thickness.[9] They also found that the segmentation errors of both borders of GCL-IPL was more common than error in one border.[9] Manual correction of segmentation errors is recommended for the resultant correction of thickness.[28]

Incomplete segmentation error

A frequently observed artifact in Spectralis and Cirrus scans was the incomplete segmentation error, where automated segmentation lines were placed properly by the software of the instrument along either the inner or outer retina but stopped before reaching the lateral edges of the scan [Figure 1b].[5] In Cirrus, incomplete segmentation lines were also observed where degraded portions of a B-scan made identification of the inner or outer retina boundary, or both, impossible. Incomplete segmentation line error almost always affects the inner segmentation line in Cirrus.[12]

Han *et al*. reported it as the most common artifact regardless of diagnosis, affecting 80.7% of all volume scans and 33.2% of all individual line scans.[3] Incomplete segmentation error rarely affects the central area.[3] These errors rarely affect the center subfield but may alter retinal thickness measurements in the peripheral subfields.[3]

As expected, diseased eyes had more frequent errors, although with both instruments of Spectralis and Cirrus, inner misidentification errors were common in the scans of normal eyes.[5]

Complete segmentation failure

Complete segmentation failure occurred where no segmentation lines were placed along either the inner or outer retina

Table 1: Contd...

Type of artifacts	Definition	Frequency (%)	Time-domain OCT	Fourier-domain OCT	Patient-related	Operator-related	Software- and hardware-related	What to do?
Patient-related								
Foveal duplication[22,23]	Double fovea in OCT image of the same eye (a type of motion artifact)	Rare	++	+	+			Repeat the scan
Segmentation shift[5]	Vertical shift in segmentation lines (with stable distance from each other) is observed in retinal image	27.6	+	+?	+		+?	Repeat the scan

*Ocular pathology related· **Poor positioning· ? Not known· !Iris blockage· &Media opacity. OCT: Optical coherence tomography· PFCL: Perfluorocarbon liquid

boundaries, described by Han *et al*.[3] It was a rare artifact in their study (4.5% Spectralis and 2% Cirrus).[3] In Spectralis, these errors sometimes occurred despite identifiable inner and outer retina boundaries.[3]

Mirror artifact (inverted artifact)

In mirror artifact, the image folds on itself around the zero line in the entire length or at the end(s) of the image. This artifact only occurs from the Fourier transformation used in OCT systems with Fourier-domain detection, including SD-OCT and swept-source OCT, and it is not present in the TD-OCT.[5] Fourier-domain detection cannot distinguish positive from negative time delays and can therefore produce OCT images symmetrical around the 0-delay line [Figure 1c].[38] In addition, there is a sensitivity roll-off in the Fourier-domain instruments, in which sensitivity decreases with increased distance from the 0-delay line.[38] The decrease in sensitivity occurs because the spectrometer of the instrument has a limited resolution, and the reflections farther away from the 0-delay produce finer interference signals.[38]

In some pathologic conditions, including retinoschisis or high myopia, the retinal image traverses the zero line.[38] Han *et al*. uncovered more common mirror artifacts in Cirrus SD-OCT (Carl Zeiss Meditec, Dublin, CA, USA) as compared to Spectralis (Heidelberg Engineering, Vista, CA, USA).[3]

Ho *et al*.[38] reported the frequency of about 9.3% for this artifact. They found that the mirror artifact occurred significantly in worse visual acuity (20/47 vs. 20/29, $P \leq 0.001$), higher axial length (26.5 mm vs. 22.8 mm, $P = 0.004$), and more myopic refraction (−4.54 vs. −0.12, $P \leq 0.001$).[10] Although the majority (73.12%) of the patients with mirror artifacts were moderately-to-highly myopic, some of their patients (19.53%) with mirror artifact were not myopic but were actually emmetropic or hyperopic, or they had retinal mass thickening (retinal detachment and wet-type AMD).[10] Mirror artifact causes segmentation break-down in the peripheral part of the image.[10] More importantly, mirror artifacts could result from poor positioning of the OCT scans, either placement too close to the 0-delay line or the extreme tilting of the scan when the OCT instrument is aligned with the scan beam off center in the eye's pupil. This would cause the retina to cross the 0-delay line at the periphery.[6] Mirror artifacts may preclude accurate quantitative OCT analysis, including volumetric and thickness analysis.[38]

Degraded image scan

The degraded image scan is a misidentification of the retinal layer. It is as if a part of the retina is broken [Figure 2a].[11] This artifact can affect the central retinal thickness map.[10] Its frequency was reported about 6.7–11.7%.[11,12]

The software cannot compensate for these defects, resulting in the errors of foveal thickness measurement. This artifact is probably because of poor imaging technique and can be resolved by refocusing on the area of interest.

The software limitation in recognition of the inner and outer retinal layers properly results in producing this artifact.[11] The presence of non-retinal disorders, such as cataract and other media opacities, is more commonly associated with this artifact.[11] As the OCT uses a near-infrared beam to acquire images, the presence of media opacity like cataract may not be a cause for a degraded image.[28]

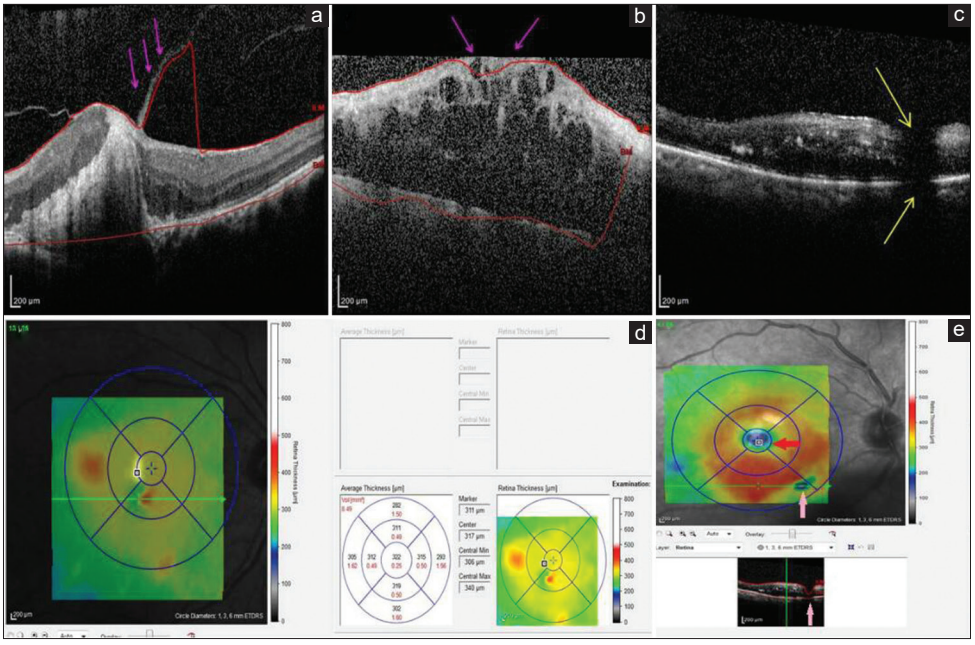

Figure 2: Several artifacts in optical coherence tomography. (a) Degraded image artifact (purple arrows). (b) Out-of-register artifact (purple arrows). (c) Blink artifact was observed as lost black section in B scan (yellow arrows). (d) Off-center artifact. (e) Foveal duplication. Red arrow shows the real location of fovea and pink arrows show the duplicated fovea in optical coherence map and related B-scan

Static or fixed image artifact

This rare (0.001–0.004%) artifact was reported by Han *et al.*,[3] specific to Spectralis SD-OCT. In static or fixed image artifact, a fixed part of image of the specific scan was shown on multiple adjacent B-scans with no changes.[3]

Linear artifact

Zuo *et al*.[13] introduced the linear artifact for the first time. They found a linear artifact as three hyper-reflective lines with the stable location in all their subjects (485 μm below the RPE) that could be beyond, beneath, or at the identical level of the sclerochoroidal interface in the enhanced depth imaging OCT.[13] They assessed 149 subjects with different conditions (normal eye, central serous chorioretinopathy, primary angle closure suspect, primary angle closure glaucoma, and primary open angle glaucoma), and they reported 81.88% frequency of this artifact in their patients.[13] In fact, this artifact is a duplication image of three layers from ellipsoid zone to RPE. The thickness of these lines was approximately the same thickness as ellipsoid zone to RPE.[13] Its importance is that it could be misidentified as sclera–choroidal interface and resultant misdiagnosis in the choroidal thickness measurement.[28] It is more frequent in clear refractive media.[13]

Operator-related artifacts

Cut edge artifact

Cut edge artifacts occurred when the edge of the scan was inappropriately illustrated (it pruned the edge of image). This artifact occurs with a frequency of 0.17–6.3% [Figure 1d].[11,15,16]

Its frequency was not different between healthy eyes and eyes with retinal disorders.[11] Due to its peripheral location, it does not affect the central retinal thickness.[11] Cut edge artifact is more common because of operator error in poor scan acquisition and appears in the first tries of the scanning, often to be eliminated by re-scanning and pupil dilation.[11] Iris blockage also produces vignetting or cut edge artifact because of OCT beam that results in the peripheral elimination of signal.[4]

Out-of-register artifact

The image is displaced vertically as much as a part of the inner or outer retina is located out of range of scan [Figure 2b].[7] Subsequently, a part of image appears to be vertically cut off.[4] The prevalence of this artifact ranges from 2.4% to 13% across different OCT machines.[7,11,12]

Ray *et al*.[11] reported the frequency of the artifacts caused by limitations in the computer software identifying the retinal surfaces (inner and outer retina misidentifications and degraded image artifact) to be 35.7% of surface maps by TD-OCT. We can categorize this artifact as one of the artifacts producing by poor scan acquisition and misalignment of the scan.[7,16] Upward deviation of the segmentation line (47.91%) occurred more commonly than downward segmentation line deviation (33.4%).[12]

The rate of occurrence of out-of-register artifact in OCT is not different between normal eyes and eyes with retinal disorders.[11] This artifact can affect the retinal thickness map reporting an erroneously thin area on the map and sectoral GCL-IPL thicknesses.[11,12]

Patient-related artifacts

Blink artifact

The blink artifact occurs during the image acquisition when the patient blinks during the process of scanning.[4] Subsequently, a part of data is lost [Figure 2c].[4] Its frequency is 0.09% in Cirrus.[12] It appears as black horizontal lines transversely on red-free image, as areas of blanks in the rendered *en face* image and macular thinning on macular map and OCT map, by the lost data in B-scan section.[4,7,17,28] In devices with higher speed and eye tracking software in image acquisition, blink artifact occurs less frequently.

Off-center artifact (grid decentration artifact)

When the central fovea is displaced over 0.25 mm from its real location in ETDRS map (topographic map and OCT B-scan data), off-center artifact happens [Figure 2d].[7] This artifact occurs because of fixation errors (eccentric fixation, very low vision, and attention deficit) with a prevalence of 3.7–16.7%.[7,17-19] Ho *et al*.[7] found that the lowest frequency of this artifact was produced by Cirrus HD-OCT (3.7%) due to its higher speed in image acquisition. This artifact was infrequent in the study of Asrani *et al*.[39] They related its rare occurrence with the presence of macular pathology in their patients that resulted in confusing accurate location of foveal center on the surface map. Presence of this artifact will cause errors in thickness map, foveal thickness measurements, and retinal nerve fiber thickness. For RTVue-100 and Topcon 3D-OCT 1000, the ETDRS-like map could be moved to the presumed central foveal region. Based on the topographic map and raster scan, we could get images in cases of eccentric fixation.

Motion artifact

The movement of the eye (eye saccade and drift, respiratory movement, alternation in head position, poor fixation, and heartbeats movement) throughout image acquisition can produce structural distortion or doubling in OCT image that is defined as motion artifact.[4] It appears as sharp alternation on the cross-section of OCT and blood vessel misalignment on red-free image and *en face* scans.[4] It has clinical importance, especially in the thickness measurement of retinal nerve fiber layer, because of its resultant segmentation error.[17] Because of greater time of image acquisition, it is more common in TD-OCT; however, SD-OCT is not free of this error.

Eye tracking system can compensate this artifact as it is in Heidelberg; however, eye tracking reduces only the transverse motion, not axial motion.[7] Better tracking system, faster image acquisition, and repeating the imaging are proposed to reduce motion artifact.[20,21,40]

Foveal duplication

Foveal duplication artifact as a patient-related artifact is produced by motion artifact because of transient micro-saccade movement of the eye.[22,41] It appears as clear double fovea in the OCT image of the same eye [Figure 2e]. Baskin *et al*.[22] reported

two cases with double fovea in their OCT. A double scan of fovea at two separate times probably produced this appearance in the same eye.[22] They explained this phenomenon with the transient micro-saccade upward producing the additional image of fovea in the downward and then central re-fixation.[22] Foveal duplication at the horizontal meridian to the anatomical fovea shown in retinal thickness map is not clearly presented in both horizontal and vertical scans.[23]

Segmentation shift

Segmentation shift, likely related to patient eye movement, was observed in Cirrus and not Spectralis. The location of the segmentation lines in the retinal inner and outer borders was stable, but a vertical shift (superior or inferior) in the retinal image was observed.[5] Due to the fixed distance between segmentation lines, segmentation shift artifact did not influence the color thickness map. Thus, it is clinically insignificant.[5] These artifacts resulted in characteristic motion waves in the layer maps of the inner limiting membrane or RPE, but not the color thickness maps.[3] The rate of this artifact was 27.6%.[5]

Perfluorocarbon liquid-producing artifact

Strampe *et al*. showed that perfluorocarbon liquid (PFCL) in the vitreous cavity can cause distortion of structures below its bubble with handheld OCT in the supine position.[14] This retinal distortion at the center of bubble is more than the edges of PFCL's bubble.[14] It could be explained by the difference of refractive indices of PFCL (1.27) compared with vitreous/aqueous humor (1.336) in agreement with Snell's law.[14] On the other hand, PFCL could work like a spherical lens with a resultant magnification of underlying structure.[14,42] It causes retinal distortion, especially outer retina below the bubble of PFCL based on its distance and radii from the noted structure.[14] Although this has been identified with PFCL, it may also occur by other tamponade, as the mechanism of artifact is different refractive index.

Discussion

OCT can provide the qualitative and quantitative information about the retinal structure with high resolution. This information has clinical importance in diagnosis and monitoring of the retinal pathologies. Artifacts can affect the accuracy of this information. The artifacts can occur in different steps, including image acquisition, processing, and analysis, and also can be related to operator, patient, and software. Many of the operator- or patient-related artifacts lead to low-image quality that consequently may lead to software failure. Identification of these artifacts has unquestionable clinical importance.

There is two main types of OCT, including time domain with the resolution of 8–10 μm and Fourier-domain OCT with the resolution of 5–8 μm.[7] Fourier-domain OCT has two types of SD-OCT and swept-source OCT.[38] The frequency of artifacts was reported higher in time-domain generation as compared to spectral-domain generation.[7] In the Fourier-domain OCT, the rate of artifact is reduced by improving the speed and sensitivity.[7,43] The higher resolution provides better visualization of structures and pathologies.[7] Earlier, some authors reported artifact frequency up to 92%.[10] Ninety and nine-tenth percent of scans had at least one artifact, and clinically important artifacts were observed in just 8.0% of scans.[5]

Ray *et al*.[11] identified some main artifacts. Subsequently, several new artifacts also were reported in different OCTs.[5,13,38] Some artifacts are correlated with a certain disease, for instance, segmentation failure, which arises frequently in diseases such as AMD and vitreomacular traction.[5]

For the first time, Zuo *et al*.[13] introduced linear artifact in the enhanced depth OCT, which may interfere with accurate choroidal thickness measurement in certain clinical conditions, such as uveitis and resulting decisions for treatment.

All of these artifacts are things the ophthalmologists should know about and look for, but some of them can also be spotted by a well-trained technician, increasing the chances that bad data will not come out. To maximize the advantages from OCT images, there is a need for operator interaction to decrease the rate of artifacts.

Better tracking system, faster image acquisition, and repeating the imaging are proposed to reduce motion artifact.[17-19] This dramatic increase in scanning speed allows for higher data acquisition with lower probability of motion artifacts.

Development of the new instruments using higher wavelengths (1050 nm) has resulted in better images by decreasing media opacity-related artifact.[28] New algorithms for data collection and analysis will work on the reduction of OCT artifacts in the future. Using other adjunctive image modalities in addition to OCT, sometimes, is crucial for correct clinical interpretation and definitive clinical diagnosis.

In addition to artifacts, the interpretation of OCT images may also be influenced by image quality. To the best of our knowledge, no study has reported the effect of image quality on quantitative analysis of OCT images.

Previous studies have reported various cutoff values for signal strength without further investigation of its influence on quantitative measurements.[44-46] Media opacities were confirmed to be a reason for signal loss during OCTA,[5] and lower image quality was associated with an increase in artifact frequency and with lower measurement repeatability in healthy volunteers. The measurement error is substantially larger in scans with lower image quality as compared to those with better quality.[47,48]

The identification of these artifacts may help in accurate interpretations of OCT images in clinical settings that can affect the diagnosis and management of different retinal disorders. Although OCTA uses the OCT technology to produce the OCTA images, and many artifacts are identical, OCTA-specific artifacts are beyond the scope of this article. The addressed subjects are not all the artifacts that we see in daily practice, and

further studies for finding other un-named artifacts are needed for the old and newly developed OCT hardware and software.

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Conflicts of interest
There are no conflicts of interest.

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