Despite new software iterations, optical coherence tomography angiography (OCTA) remains challenged by artifacts that can disrupt volumetric data and the clarity and usefulness of images.

Rapid advances in the quantitative data outputs from OCTA technology have spurred its use in clinical trials as well as hopes of wider use. But OCTA “is still a relatively new technology, still rapidly evolving,” cautioned SriniVas Sadda, MD, at the Doheny Eye Institute in Los Angeles. “There are new types of artifacts specific to OCTA, and these are not necessarily going to disappear completely, regardless of software advances.”

A noisy problem. Dr. Sadda noted that each device uses its own hardware platform and software algorithms. “You can’t just interchange the data between devices, because they use different approaches to extracting and processing information,” he said. “Even in the perfect situation, with no errors during the acquisition or processing of data, there is going to be some ‘noise’—and if you repeat the same scan a minute later, it’s not going to be exactly the same.”

Thus, Dr. Sadda said, ophthalmologists need to be able to decipher whether a change they see in the images is meaningful or not.

Elucidating the Issue
A study published earlier this year in *JAMA Ophthalmology* detailed the prevalence of various artifacts in 406 OCTA images of eyes with diabetic retinopathy. Researchers at the University of Wisconsin-Madison documented at least one artifact in 395 images (97.3%); artifacts severe enough to disrupt the reliability of quantitative outputs were found in 217 images (53.5%). Given the prevalence of artifacts and lack of research into the link between artifacts and quantitative outputs, the authors cautioned against basing clinical decisions on OCTA at this time.

“There was very little being reported in the literature about artifacts, because people need to sit with the images and look at them for a long time to understand the artifacts,” said study coauthor Amitha Domalpally, MD, PhD. “Severe artifacts can affect the data, and we found them in more than 50% of the images. We asked, can we look at these images and their vascular density measures and say—reliably and confidently—that the nonperfusion is truly there; or is it because of the artifact? We felt that severe artifacts inhibited us from reliably extracting those measurements.”

The findings spurred additional research: Dr. Domalpally is now evaluating the specific impact of artifacts on measurements. The researchers are taking scans, inducing artifacts, then removing them “so that we can see the image with and without the artifacts to compare the measurements,” she said. “We are looking to identify what can be measured in the OCTA images to help the research go forward.”

Common Artifacts With OCTA
Motion artifacts. OCTA devices take multiple scans from one location, comparing them from one moment to the next. With stable fixation, what has changed is assumed to be blood flow. But movement of a patient’s eye, head,
or body can cause blood flow decor-
relations or fluctuations in the scan,
known as motion artifacts.

“Of the various OCTA artifacts that
can degrade an image, the most promi-
nent are related to motion,” said David
Sarraf, MD, at the Stein Eye Institute in
Los Angeles. “Any loss of fixation due
to poor vision or because the patient is
not comfortably sitting at the machine
can result in artifacts that can degrade
the image.”

With each algorithm iteration, tech-
nicians have been able to produce better
quality images, Dr. Sarraf said. “Some
of the new algorithms have tracking
systems designed to limit motion arti-
facts. But if there are vertical or hor-
izontal white lines, sihouetting, or
crisscrossing lines on the image, the
technician should repeat the scan; the
acquisition time for scans is relatively
short.”

**Segmentation artifacts.** OCTA
is based on 3-D data viewed on 2-D
screens. Analyzing a particular plane
(more precisely, a thin slab) depends on
where that slab begins and ends.

“Most devices automatically decide
where a border should be based on
where different layers of vessels should
be positioned,” said Dr. Sadda. “Differ-
ent machines may differ in where they
divide the retina into different layers.”

With traditional OCT, ophthalmo-
lologists are used to viewing images in
a cross-section (e.g., a B-scan). “You
can look at your OCTA data the same
way, by looking at the flow information
superimposed on the B-scan,” said Dr.
Sadda. “But when we’re doing quanti-
fication, we are generally using en face
OCTA images from different slabs, and
that’s where segmentation artifacts can
manifest.”

Equally concerning, Dr. Sadda said,
is the role of disease in disrupting these
automated algorithms. “If a disease
takes out a layer of the retina, where
should the boundary be?”

**Projection artifacts.** Projection
artifacts arise when blood flow of su-
perficial layers of the retina is projected
onto deeper structures below. If there’s
motion in a superficial retinal vessel,
for example, there can also be motion
in a shadow behind it.

“OCTA doesn’t distinguish whether
it’s the original structure or a shadow;
it’s just reporting a change at one loca-
tion from scan to scan,” said Dr. Sadda.

“The trickiest part of looking for a pro-
jection artifact is that you won’t see it
clearly everywhere below that structure;
the projection artifact will be most
apparent wherever you have the next
bright object below.”

Even with a device’s projection
artifact tool enabled, Dr. Sadda advises
cautious interpretation and healthy
skepticism when something looks
like blood flow where it’s unexpected.

“Look at your structural OCT en face
image, and if there’s a brightly reflective
structure there, then that heightens
your suspicion,” he said. “Then look
at the B-scan with the flow overlay. If
you see flow in those deeper layers that
perfectly matches flow above it, then
be pretty suspicious that’s projection
artifact. If there’s no flow above it, and
you just see the flow in that deeper
structure, then it’s less likely to be a
projection artifact.”

All three experts suggest that it takes
time to correctly interpret OCTA images.

“You have to have the tools and the re-
view station set up in your office so you
can view your OCTA data in this way,
and it requires a few minutes to look
for these things,” Dr. Sadda said.

**Signal attenuation artifacts.** For
OCTA to work, light has to penetrate
multiple layers to scan the deeper struc-
tures of the retina. “If there’s a loss of
signal by the time it reaches the deeper
layers such as the choriocapillaris, it can
result in a signal attenuation artifact,”
said Dr. Sadda.

“Loss of signal impacts your ability
to detect whether or not there is flow,
which is why your technician has to
maximize the signal strength,” he said.

“If the signal quality changes a lot
between visits or acquisitions, that can
artificially impact the appearance of the
vessels and their measurements.”

And such changes can lead to faulty
diagnosis. The image “can suddenly
look like much worse flow or vessel
density,” Dr. Sadda said, “but maybe
that patient developed a significant
cataract over the years that made the
signal much worse.”

**How to Improve OCTA Interpretation**

**Use of “four-up” image review.** Dr.
Sadda recommends looking at four
images displayed together as the ideal
method for spotting artifacts such as
segmentation and projection.

“When you look at your OCTA
data, don’t just look at the en face slab;
pay attention to the corresponding
B-scan and the structural OCT,” he
said. “Essentially you’re looking at a
‘four-up’ image display: your OCTA en
face, your structural OCT en face from
that same location, your standard OCT
B-scan, and the B-scan with the OCTA
data as the flow overlay.”

**Technician training.** Adequate train-
ing can help reduce artifacts such as
projection and motion, for example,
by having the patient move their eye to
clear vitreous obstructions or repeating
scans when obvious artifacts or loss of
signal are apparent.

“Train your technicians to look for
potential problems such as evidence of
motion artifacts, and if they see discon-
tinuities, have them repeat the scan,”
said Dr. Sadda. “Train them to maxi-
imize the signal by using artificial tears
or having patients blink, and if a scan
doesn’t meet minimal signal require-
ments for reliable data, repeat the scan.”

**Patient instruction.** Coaching
patients may also help. “The technician
needs to coach patients not to move
their eyes and make sure their heads are
comfortable within the chin rest and
headband,” said Dr. Sarraf.

**Patient selection.** There is one caveat
to be aware of, Dr. Sarraf said: “For
patients with severe central vision loss
and severe macular pathology, such as
advanced disciform scar or late-stage
macular degeneration due to geograph-
ic atrophy, fixation can be very diffi-
cult.” As a result, he said, “these patients
are not optimal for OCTA testing.”

**A Role for AI?**

As with many technologies, artificial
intelligence (AI) is making inroads into
OCTA devices. The experts offered two
possible outcomes of this combination:

**Production of better images.**
The algorithms that allow OCTA to
derive blood flow changes at
both superficial and deep levels might eventually be used to alert a technician to the need for a repeat scan. “Maybe we’ll reach a stage in which there are algorithms that can be inserted into the camera, [prompting it to] take a picture and to tell the technician right away to retake the image,” said Dr. Domalpally.

**Prediction of disease progression.**
In another scenario, AI might be used to boost OCTA’s ability to predict the progression of disease.

“OCTA is an amazing diagnostic modality that helps us detect choroidal neovascularization and choroidal ischemia in various degenerative and inflammatory disorders, and it’s an important resource to identify non-perfusion and ischemia, especially in retinal vascular diseases,” said Dr. Sarraf. However, he pointed out, “the predictive power of OCTA has fallen short. We haven’t been able to develop any reliable way to use OCTA to predict progression and activity of disease. We’re starting to look into AI, which can integrate information on a much grander scale, as a potential way to use OCTA to predict outcomes.”


Dr. Domalpally is research director at the Fundus Photograph Reading Center, Department of Ophthalmology & Visual Sciences, University of Wisconsin-Madison. **Relevant financial disclosures:** None.

Dr. Sadda is president and chief scientific officer of the Doheny Eye Institute and professor of ophthalmology at the David Geffen School of Medicine, University of California, Los Angeles. **Relevant financial disclosures:** Carl Zeiss Meditec: S; CenterVue: C,S; Heidelberg: C,S; Nidek: S,L; Optos: C,S; Topcon: S,L.

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For disclosure key, see page 8. For full disclosures, see this article at aao.org/eyenet.