Intraoperative optical coherence tomography (OCT) of the posterior segment is a relatively new application of a familiar imaging modality that promises to improve surgeons’ ability to visualize intraocular structures and to provide qualitative and quantitative information that has previously not been available during surgery.

Intraoperative OCT has been used in other surgical fields. It has been reported to facilitate evaluation of breast tumor margins in real time during breast-conserving surgery, to help visualize structures of the inner ear during middle ear surgery, and to allow assessment of radial arteries before and after bypass grafting.

The use of similar technology in ophthalmology is now emerging. Dayani and colleagues found the use of a handheld spectral-domain (SD) OCT instrument (Bioptigen, Durham, NC) to be an efficient method for visualizing macular pathology in posterior segment surgery. Obtaining repeated images during surgeries for macular hole, epiretinal membrane (ERM), and vitreomacular traction, they documented changes in retinal contour and macular hole configuration; in some cases, intraoperative imaging helped to identify additional pre-retinal membranes. The utility of this modality, however, is limited due to the handheld nature of this instrument. The unit must be properly stabilized to obtain good images, and potential complications may occur if the instrument disturbs the sterility of the operative field. This handheld OCT system also has limited ability to provide quantitative measurements and lacks a normative database.

Early experience with an SD-OCT device connected to an operating microscope has been presented. Investigators said this technology offered additional information to the surgeon, they reported that improvements are needed in resolution and integration to facilitate its practicality.

PORTABLE SYSTEM IN THE OR

The iVue SD-OCT (Optovue, Fremont, CA) is a commercially available, portable OCT system with quantitative analytic capabilities. I am currently using this device, in combination with a floor stand system (iStand, Optovue), in the OR under an ongoing single-surgeon institutional review board (IRB)-approved study of a series of 50 consecutive macular surgery cases. The stand and OCT unit are configured for intraoperative use and covered with a sterile, commercially available drape designed for an ENT surgical microscope (Figure 1). The OCT unit and stand are moved in and out of position in a matter of minutes to obtain intraoperative images at various stages throughout the procedure for vitrectomy patients in which macular surgery is performed. The patients are imaged intraoperatively before the first incision and at various points during the procedure.

Zonal changes in retinal thickness were evaluated in four pseudophakic patients by manually aligning pre- and post-membranectomy images and performing automated digital subtraction (Figure 2). Surgical procedures included pars plana vitrectomy with peeling of the internal limiting membrane (ILM) and/or ERM with indocyanine green (ICG) or triamcinolone acetonide staining of the membranes. One patient underwent concomitant removal of perfluorocarbon liquid (PFCL) bubbles (Figure 3). Image quality was affected by the clarity...
and hydration of the cornea and the status of the lens. PFCL bubbles did not affect the clarity of the retinal image, except for minor distortions at the edges of the bubbles. In all cases, there was a trend toward thinning of the central macula and paramacular thickening after membranectomy. Mean thickness changes ranged from −24 µm to +8 µm. We concluded from this short series that the portable SD-OCT unit and stand provided a practical method for qualitative and quantitative intraoperative retinal evaluation.

**POTENTIAL USES**

The intraoperative combination of OCT and stand allows the surgeon to examine the anatomic results of vitreoretinal surgery from a sagittal, 3D perspective, one that cannot be seen with the limited depth perception of the operating microscope. I find it most useful for evaluating the macula pre- and post-macular membranectomy. Dyes such as trypan blue or off-label ICG, or markers such as triamcinolone acetonide, may not stain optimally, and there is always the concern that excess dye or steroid can get into the anterior chamber in pseudophakic patients, causing visualization problems. In addition, off-label ICG use has the potential for toxicity to the retinal pigment epithelium (RPE).

Intraoperative OCT offers a practical alternative to these dyes and markers, potentially avoiding the problems associated with putting these substances in the eye in selected cases. In addition, macular membranectomy procedures can be staged, with removal of the ERM first, followed by evaluation of the macula with OCT to determine if residual tractional changes warrant more aggressive ILM removal. The number of reoperations for residual tractional changes may also be reduced with intraoperative OCT evaluation.

Another potential application of intraoperative OCT is in the evaluation of macular holes after membranectomy and prior to gas injection. Macular holes have been observed to attain almost complete closure with intraoperative OCT after ILM peeling and before gas injection. Being able to observe the configuration of the macular hole immediately after the membrane peel may allow the surgeon to alter his or her decision with regard to the nature of the gas to be used and to choose shorter acting gases, or even air, if the hole is essentially closed at this stage.

Intraoperative OCT also allows the surgeon to detect subtle choroidal detachments as well as iatrogenic holes that can occur with complex membranectomy in proliferative vitreoretinopathy and proliferative diabetic retinopathy cases, which may need laser retinopexy if determined to be full-thickness. Residual tractional retina elevations from pre- or subretinal membranes can also be visualized, especially after PFCL instillation during retina reattachment. Positioning of posterior radioactive plaques for melanoma treatment could also be determined with greater precision.

Nonretinal indications, finally, could include evaluation of perioperative cystoid macular edema after cataract extraction, sclerotomy and cataract wound architecture, and glaucoma tube shunt placement.

**GETTING THE BEST RESULTS**

The best intraoperative SD-OCT images are obtained in patients who are pseudophakic and have clear cornea and vitreous. If a cataract progresses during surgery, or if the cornea becomes edematous, it is harder to get the immediate postsurgical image. It is important to keep the cornea well hydrated and work efficiently to keep operative time to a minimum.

Intraoperative OCT with the iVue and iStand can be performed under various types of anesthesia. With local anesthetic, the patient can sometimes fixate on the OCT’s fixation target. With general anesthesia, the patient tends to settle in primary position, which also helps with macu-
COVER STORY

lar imaging. Instruments, such as forceps or a globe fixation ring, allow the surgeon to quickly align the macula with minor movements of the patient’s eye or head, taking advantage of the hands-free operation of the iVue with its footpedal attachment. This allows optimal macular imaging to be performed within several minutes.

CONCLUSION

Until SD-OCT can be successfully integrated into the operating microscope, the iVue with iStand provides an efficient, practical method for intraoperative retinal imaging that can easily be incorporated into retinal surgical practice, adding a novel perspective of the retina. This allows the surgeon real-time assessment of surgical results, potentially enhancing surgical outcomes and reducing the need for reoperations, thereby avoiding additional costs, burden on the health care system, and morbidity for the patient.

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